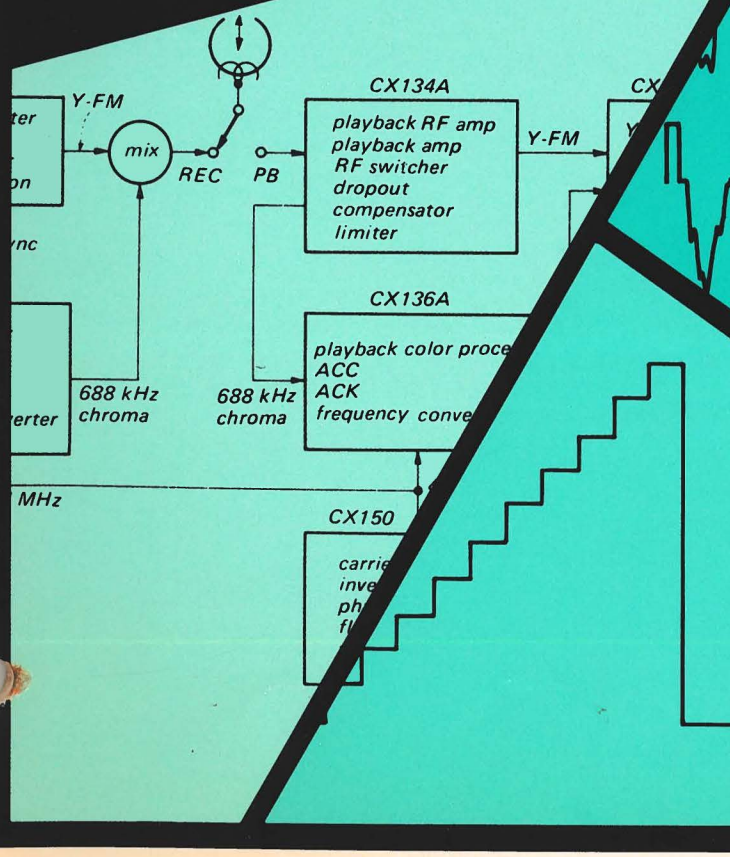
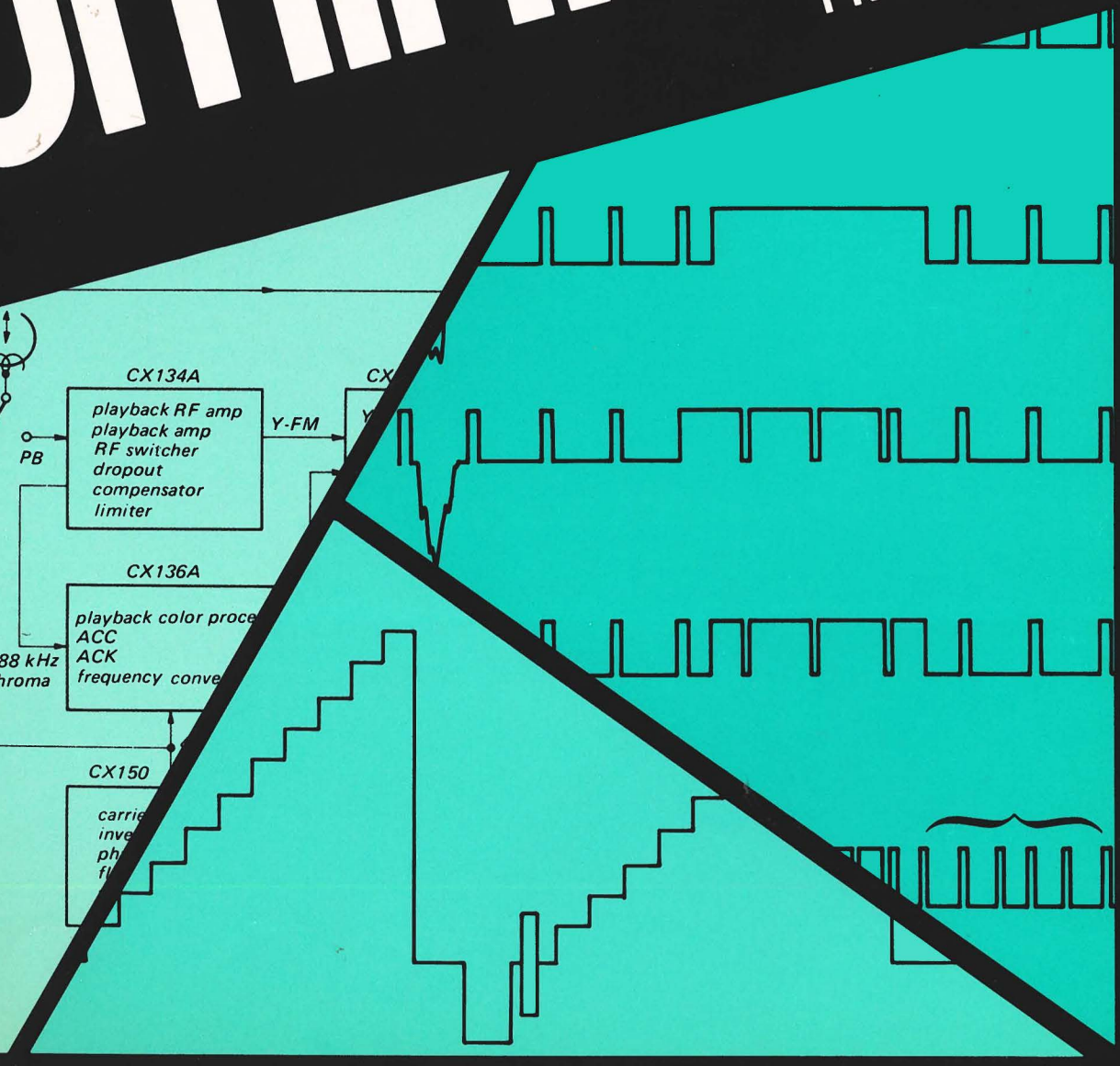
SONY BASIC VIDEO RECORDING COURSE

BOOKLET #7

LUMINANCE PROCESSING





SONY®

BASIC VIDEO RECORDING COURSE

BOOKLET 7

LUMINANCE PROCESSING

Introduction

In this lesson we will examine the circuits that process the luminance signal. We will review alignment procedures to get some experience of the reasons behind methods, and then look into the basic troubleshooting philosophy.

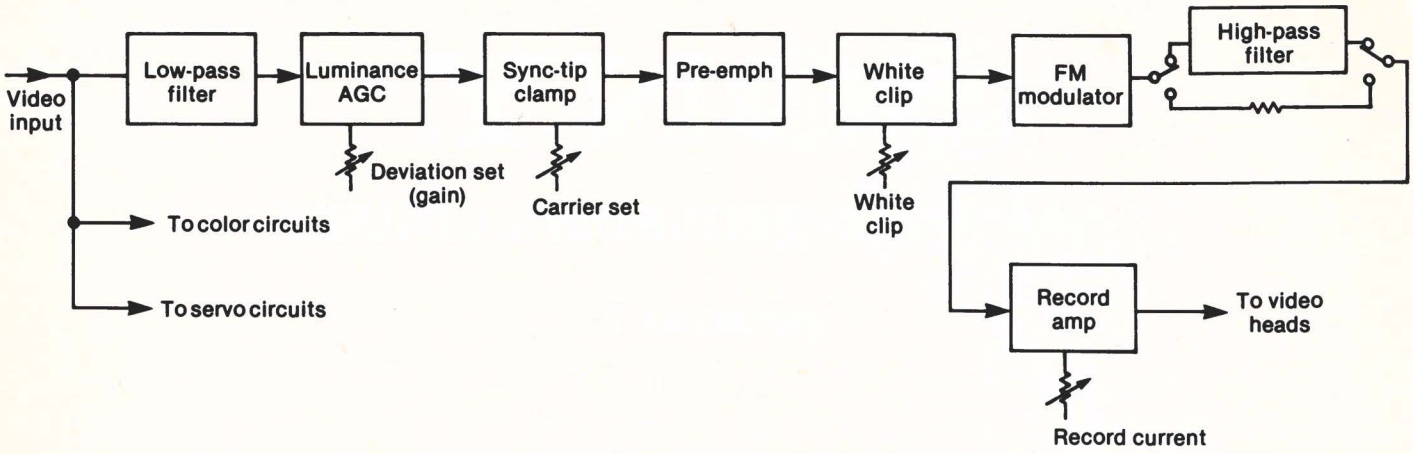


Fig. 1. Basic luminance-record circuits.

1. TYPICAL LUMINANCE CIRCUITS

The circuits chosen as representative in this section illustrate common practice. Some have been selected from older models because discrete component circuits are used and it is easier to see what is going on when entire sections are not buried within a single IC chip.

Record Circuits. Fig. 1. shows a basic block diagram of the luminance-record circuits. The heart of the system is the *frequency modulator,* a voltage-controlled oscillator, that turns the video signal into an FM signal with its attendant sidebands. The circuits to the right of the modulator are essentially a current or *record amplifier* capable of supplying sufficient current drive to the video heads to drive the tape into magnetic saturation at the peaks of both negative and positive signal excursions. The frequency characteristics of the record amplifier are designed to provide some degree of *pre-equalization,* a boost at the low end of the spectrum to compensate for playback characteristics. In machines that handle color a *high-pass filter* is switched into the feed path to the record amplifier to remove the lower FM sideband in the region below 1 MHz. This provides spectrum space for the down-converted color signal that is centered at 688 kHz.

The circuits to the left of the FM modulator set up the operating conditions for the modulator. A *clamp circuit* ties video sync tips to the d-c voltage level that makes the modulator operate at the low end of the deviation range. A *deviation set control* determines peak-to-peak video that is fed to the modulator. Since sync has been clamped, the peak amplitude of the signal determines maximum deviation. The *white clip control* prevents signal excursions, particularly small areas in the peak-white region, from driving the modulator too far past the maximum deviation range. Excessive deviation produces signals that are beyond the capability of the playback system to reclaim. Under these conditions, noise appears in playback where peak-white signals, particularly in small-area highlights, should be.

The first stage in signal processing for home and industrial machines is an *automatic gain control (AGC)* stage to keep video levels into the modulator at a constant level despite variations from the signal source. The sources can be a wide variety of video cameras, other VTRs and off-air signals from TV tuners. The video AGC system has the unique requirement that it should not respond to variation in average picture level (APL). That is, changes in scene brightness as the camera pans from bright to dark subjects should not be opposed by the AGC system. To this end, sync amplitude is made the reference for signal amplitude.

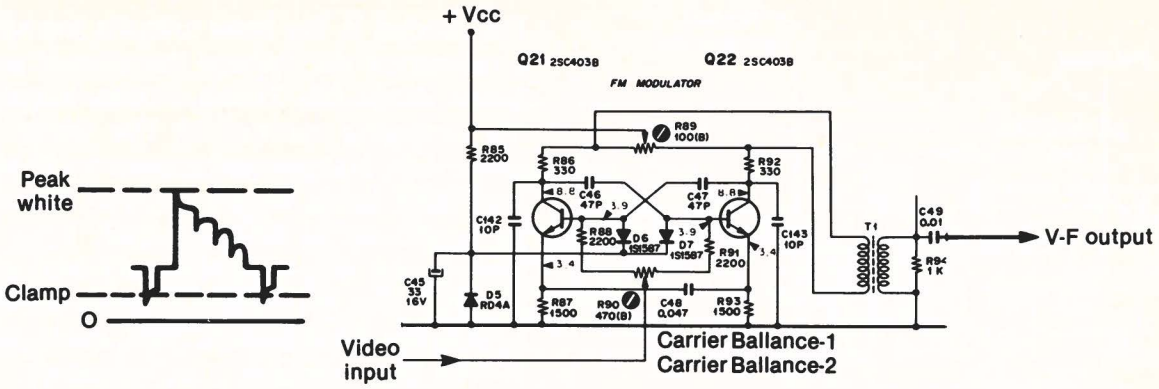


Fig. 2. Basic FM Modulator. (VO-1800).

FM Modulators. The modulator is a voltage-controlled oscillator (VCO). The most common type used in industrial and home VTRs is an astable (free-running) multivibrator. Fig. 2. is an example taken from the VO-1800. It differs, basically, from the monostable multivibrator studied in the previous lesson in that it has two unstable states and coupling capacitors in both collector-to-base feedback coupling networks. At the start of one of the unstable states Q21 turns on dropping its collector voltage to a few volts. C46 then dumps the charge it had accumulated in the previous half cycle through R91 and R90 holding Q22 in cutoff. During that time C47 charges through the base-emitter junction of Q21 and R92. When the discharge of C46 tapers off to the point where the base voltage of Q22 swings 0.6 volts above its emitter voltage Q22 turns on. This triggers a reversal of roles. The collector voltage for Q22 drops and C47 then discharges to hold Q21 in cutoff.

The free-running frequency is determined primarily by the RC time constant of the cross-coupling networks. But voltage control of frequency is achieved by returning both bases to a variable voltage supply. Raising the base voltage supply serves to bring the cutoff stage into conduction sooner. The off intervals on both sides shorten and frquency rises. Fig. 3. shows the voltage-frequency characteristic. The d-c clamp level determines the lowest frequency at which the modulator will operate and video, which changes the voltage in the positive direction, drives the modulator to the top of its operating range.

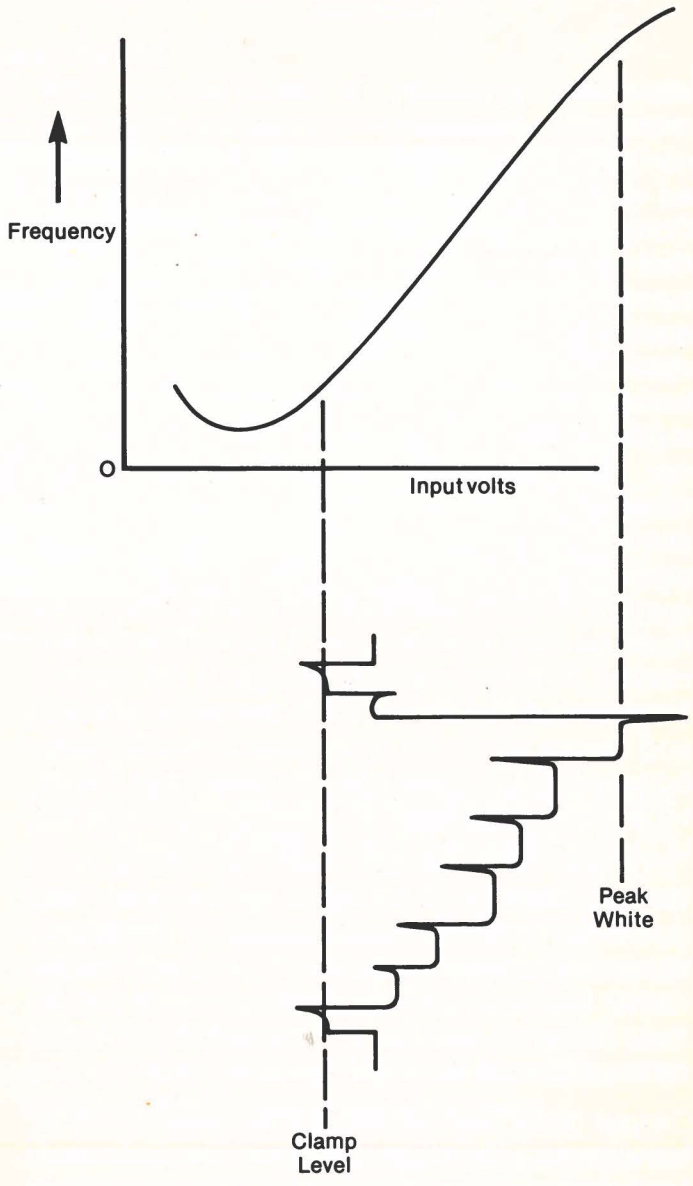


Fig. 3. Modulator input voltage-output frequency characteristic.

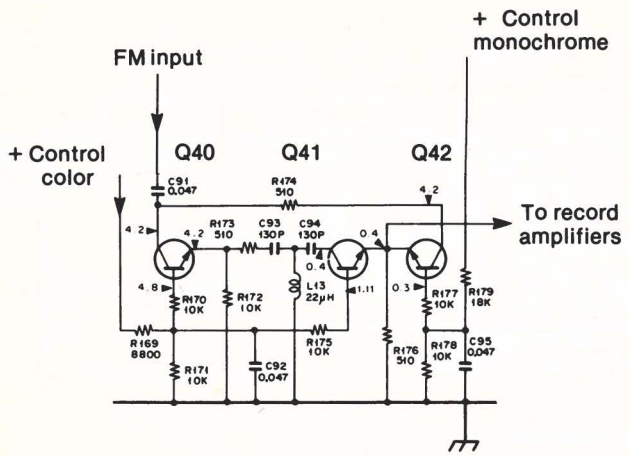


Fig. 4. High-pass filter switched into FM feed in color-record mode.

Waveform symmetry is important in VTR modulators because we are dealing with a carrier frequency that is on the edge of the intended video passband (3.8 MHz for the U-matic). Compare this to other modulating systems that you know about. In most the carrier is at least several times the highest modulating frequency. A filter effective in removing carrier ripple at 3.8 MHz would seriously cut into video bandwidth. The scheme used in the FM demodulator, as you will see, is to double the carrier frequency prior to demodulation. This makes the carrier ripple frequency high enough to remove with low-pass filters that preserve video signals. For the doubling system to work, however, the carrier waveform must be very symmetrical. Loss of symmetry results in some residual energy at the carrier frequency. This cannot be removed by filtering and shows up in the picture as a fine herringbone pattern. It looks just like broadcast FM interference in ordinary TV sets. Residual carrier is known as *carrier leak* in VTR parlance.

The adjustments to minimize carrier leak in the modulator act to make both sides of the multivibrator electrically identical. They are called carrier balance controls. In the circuit of Fig. 2. they balance the base and collector resistance, R89 and 90 respectively.

Output from the modulator is coupled by a transformer (T1) that changes the balanced feed from both collectors to a single-ended feed, referenced to chassis ground.

The diodes in the base circuits are returned to a reference d-c voltage developed across the Zener diode D5. These diodes supply part of the charging current to the cross coupling capacitors and prevent excessive charging current from being drawn through the base-emitter junctions of Q21 and Q22. Thus the transistors are not driven deeply into saturation and the turn off delays associated with deep saturation are avoided. This extends and improves high-frequency performance.

Switchable High-Pass Filters. Most Sony machines automatically alter FM bandwidth to optimize both color and monochrome performance. A high-pass filter is switched into the feed path to the record amplifiers to provide spectrum space for the color signal which is centered at 688 kHz. If a monochrome signal is being recorded this is switched out to preserve the entire lower FM sideband. The result is greater resolution in the monochrome mode. Switching is done electronically. The switching voltages are developed by a "color-killer" circuit that looks for color burst in the signal being recorded.

Fig. 4. shows an example of electronic switching. The FM feed from the modulator is applied to the collectors of Q40 and Q42. These operate as series switches. When positive control voltage is applied to the base bias networks the transistors saturate, effectively connecting collectors to emitters. If a color signal is being processed, control voltage is applied to R169 and both Q40 and Q41 saturate. FM signals then pass through the high-pass filter formed of C93, L13 and C94. In the monochrome mode, Q40 and Q41 are cut off and Q42 saturates to pass the full-bandwidth FM signal.

Record Amplifiers. The record amplifiers shown in Fig. 5. are typical of early U-matic designs. Two sets of amplifiers are used in this case, one to drive each of the two video heads. Separate record-current potentiometers at each of the inputs to the amplifiers permit record current to be optimized for each head. Wide band amplifiers Q45 and Q46 provide sufficient drive current for the class A power output stage Q47. The variable series resistance R195, acts as a reactive voltage divider with the

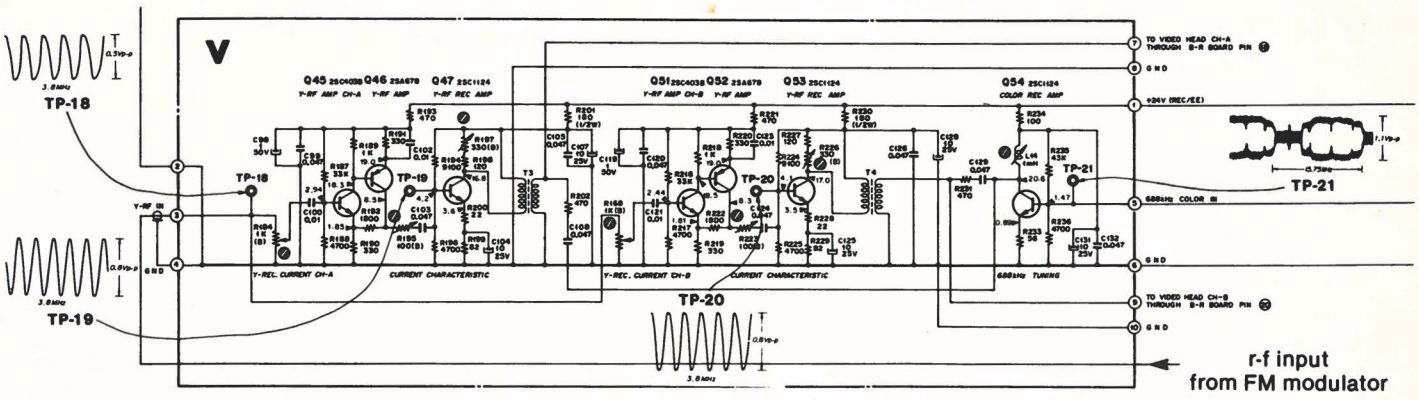


Fig. 5. Record amplifiers. (VO-1800).

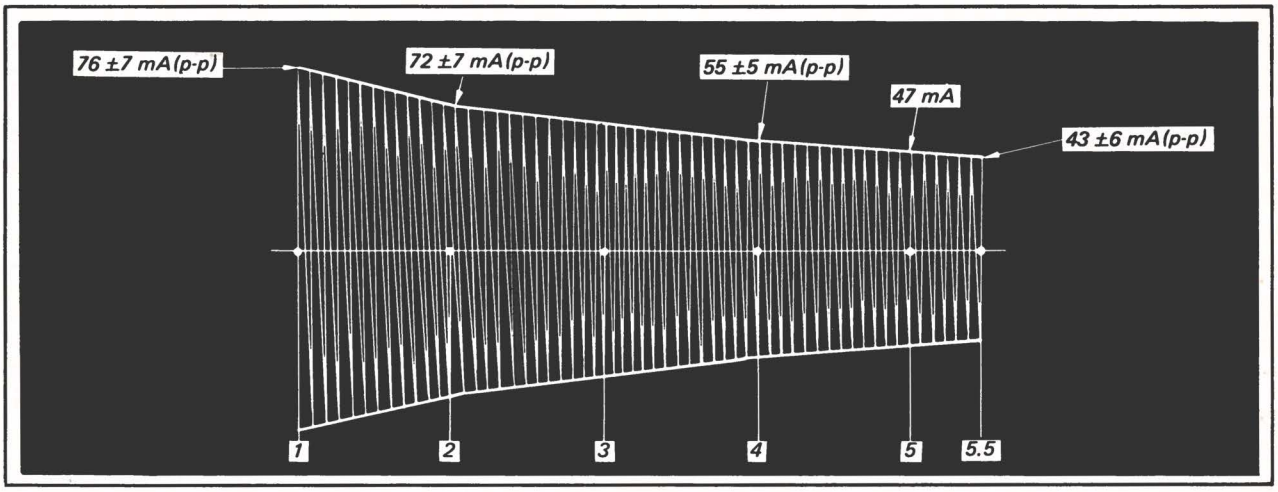


Fig. 6. Record amplifier frequency characteristic.

capacitive input impedance of Q47 to alter high frequency gain. Output from Q47 is transformer coupled to provide a current step up to the video heads. The variable resistance across the primary of the coupling transformer provides adjustable damping to control the effects of resonance in the transformer video head circuit.

The current characteristic controls are adjusted by monitoring video head current using an oscilloscope equipped with a current probe. Video sweep signals are applied to the input, TP-18 in this cae, and the current characteristic controls set for the frequency response shown in Fig. 6. In some VTRs the record amplifier is adjusted for a flat response; no pre-equalization is used.

Also shown in Fig. 5. is the color-record amplifier Q54. This amplifier is broadly tuned to the down-converted color subcarrier at 688 kHz and its output is coupled via C129/R231 and C108/R202 to be fed in parallel with the Y-FM signal to each of the video heads. The color record current into the heads is some 10 dB below the FM current. Color signals at 688 kHz are recorded directly, with the luminance FM signal acting as high-frequency bias.

Now let's turn to the circuits that ready the input luminance signal for frequency modulation.

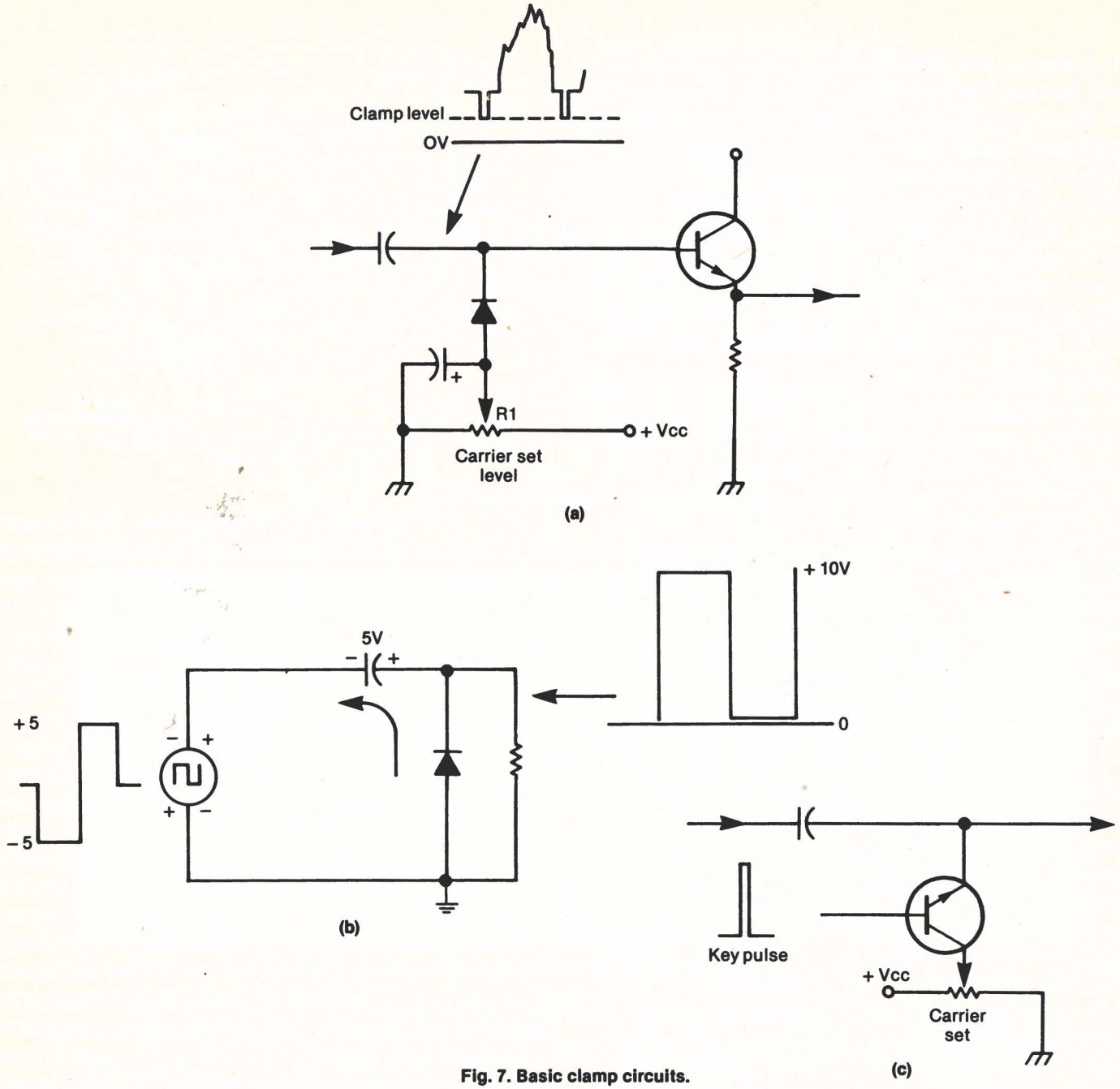


Fig. 7. Basic clamp circuits.

Sync-Tip Clamp. A basic sync-tip clamp is shown in Fig. 7(a). Its function is to tie video sync-tip voltage to the d-c level that makes the modulator operate at the bottom of its deviation range. That d-c level is determined by the setting of R1, which has been called both carrier set or sync tip frequency in Sony machines.

Circuit operations can be easily understood using a square wave input and the diode clamp returned to ground as shown in (b) of the figure. During negative half cycles the diode conducts, and neglecting diode voltage drops, the coupling capacitor charges to five volts with the polarity shown. During positive half cycles the +5 volt swing plus the voltage stored on the capacitor are in series and the full 10 volts appears across the load. Thus the negative excursions are clamped to ground and the full signal swing is positive going. By adding a d-c voltage between the anode of the diode and ground the negative going peaks of the square wave can be clamped to any desired level. If the square wave is replaced by a video signal,

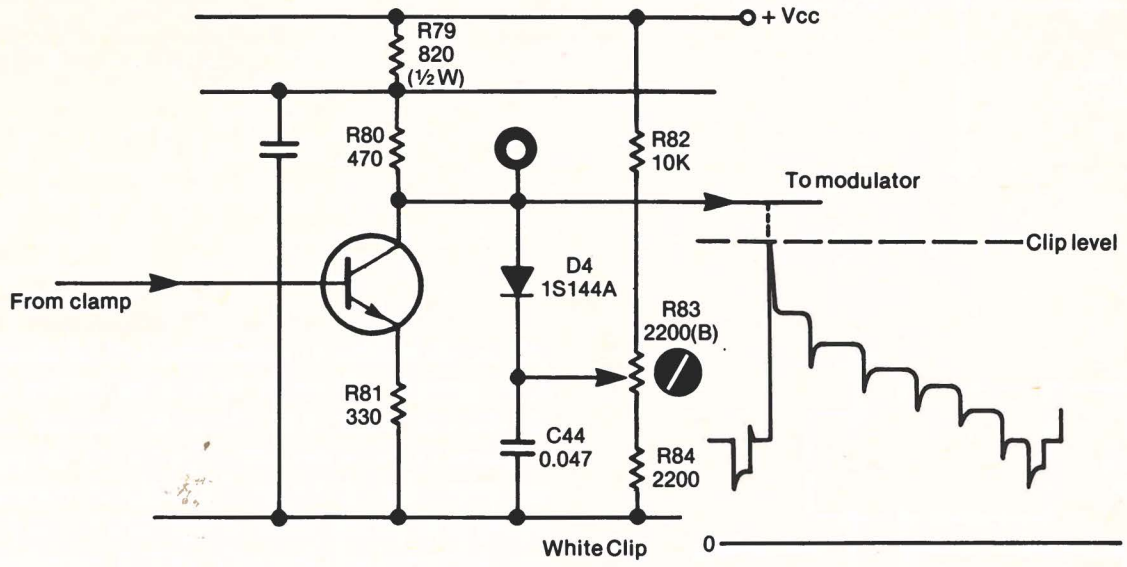


Fig. 8. White-clip circuit.

the negative peaks, sync tips in this case, are clamped to the carrier set level and the entire signal excursion swings in the positive direction from that level. The capacitor assumes a charge determined by average scene brightness, increasing as brightness increases. Clamps of this type are also used in TV sets to restore the d-c component of the signal lost in a-c coupling circuits.

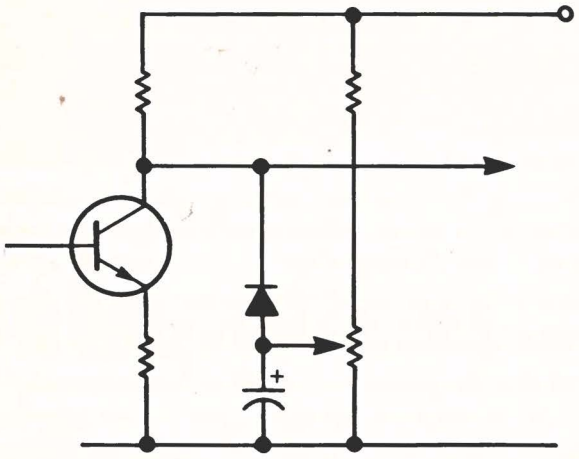
In some cases keyed clamps are employed. Here the diode is replaced by a transistor as shown in Fig. 7(c). It works the same way except that the transistor is driven to saturation by a key pulse, usually separated horizontal sync, to clamp sync tip to the carrier set level.

Where diode clamps are used, carrier set can be adjusted by removing input video. The clamp level alone is then applied to the FM modulator and the control is set to make it run at the low end of the deviation range (such as 3.8 MHz for U-matics). A different approach must be applied where keyed clamps are in use, because removal of signal opens the clamp transistor, isolating the carrier set level from the modulator.

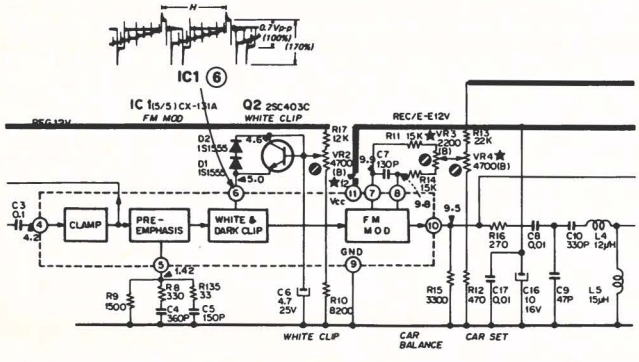
The clamps must work into a relatively high load impedance so that the coupling capacitor can retain its average charge. In most cases a direct-coupled emitter follower is the buffer between the clamp and the base input to the modulator.

White Clip. The function of the white-clip circuit is to limit the positive-going excursion of signal at the input to the modulator. Preemphasis boosts high video frequencies, as can be seen by the voltage spikes at signal transitions in the drive signal to the modulator. The spikes at the leading edges of positive going transitions at peak white tend to drive the modulator above maximum deviation. To prevent the effects of overdeviation, the white clip circuit shears off all voltage transitions that exceed peak white by a designated degree. A typical circuit is shown in Fig. 8. Diode D4 is normally nonconducting, but positive going signals at the collector of Q20 that rise 0.6 volts above the level set at R83 cause the diode to conduct. This effectively shorts the collector voltage to the level set at R83 and collector voltage can rise no higher.

In most cases, the white clip level is set at 140% considering sync tip to peak white to be 100% as shown in the figure waveform.



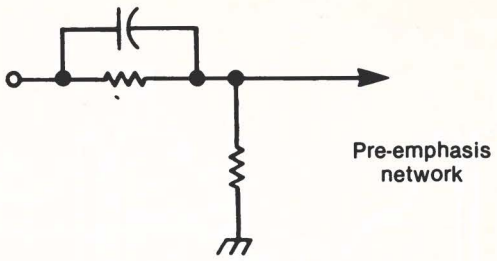
(a) Dark clip



(b) White and dark-clip

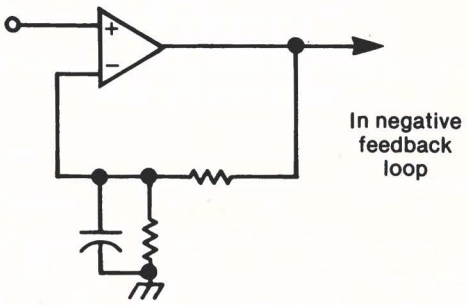
Fig. 9. Dark clip circuits.

Dark Clip. The effects of pre-emphasis also produces voltage spikes that extend in the negative direction. Where a large degree of pre-emphasis is used, the voltage spikes at negative going transitions at low brightness levels tend to drive the modulator below the carrier set frequency. Fig. 9(a) shows a dark clip circuit. It is the same as the white clip circuit except the diode is reversed; it is set to limit negative-going signal excursions. The circuit shown in (b) of the figure is taken from an early Betamax. It clips both white and dark levels. The transistor is connected as a diode using the base-emitter junction. The signal can swing about 1.2 volts (0.6 + 0.6) in the positive direction above the voltage set by VR-2 at which time D1 and D2 come into conduction. The signal can swing about 0.6 volts below the level at VR-2, at which time the base-emitter junction of Q2 conducts. VR-2, the white clip control, is set to limit the negative-going excursion.



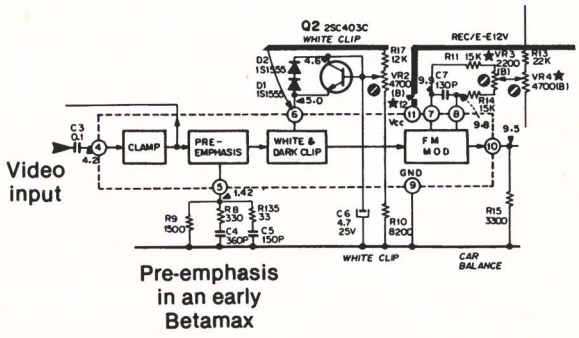
(a)

Pre-emphasis. Pre-emphasis is added by an RC network either before or after the clamp. It is either a series network like that shown in Fig. 10(a) or an integrating network placed in the negative feedback loop of an amplifier as shown in (b) of the figure. Both serve to provide high-frequency boost. Placing the network in a degenerative feedback path facilitates external connection to integrated circuits where it is not possible to install series components in the signal path. An example is shown in Fig. 10(c).



(b)

Subcarrier Trap and Luminance Delay. In those machines that use the color-under process, the 3.85 MHz carrier is trapped out of the luminance feed to the modulator. Since color is diverted and processed separately the color signal must be removed from the luminance path to minimize the beat between the original and heterodyned color signal when the luminance signals and chroma signals are rejoined in playback. In addition the luminance signal is delayed to maintain correct relative timing with the chroma signal which undergoes a natural time delay due to color-bandwidth restrictions. Here again in Sony machines, provision is made for maintaining full video bandwidth when monochrome signals are processed. Fig. 11. shows the switching circuit used in an early Betamax. When color signals are processed, a burst detection circuit provides the control voltage, called ACK for automatic color killer, that transfers the electronic switch to select the signal feed that contains the 3.58 MHz trap and the delay line. In the monochrome mode the signal is fed through R32, which attenuates the signal so that the same level is obtained at the output of the switch in both modes.



(c)

Fig. 10. Pre-emphasis networks.

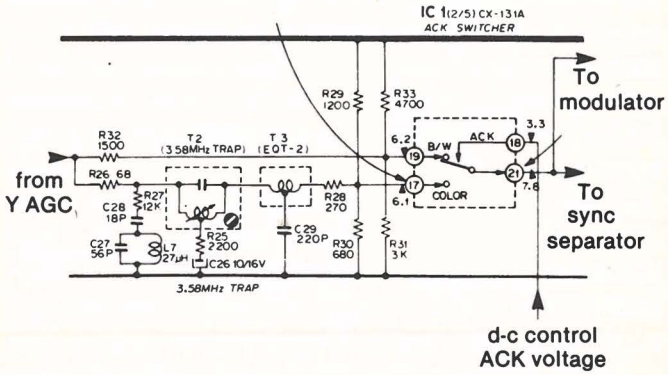


Fig. 11. Luminance delay and 3.58-MHz trap inserted into video feed in color-record mode.

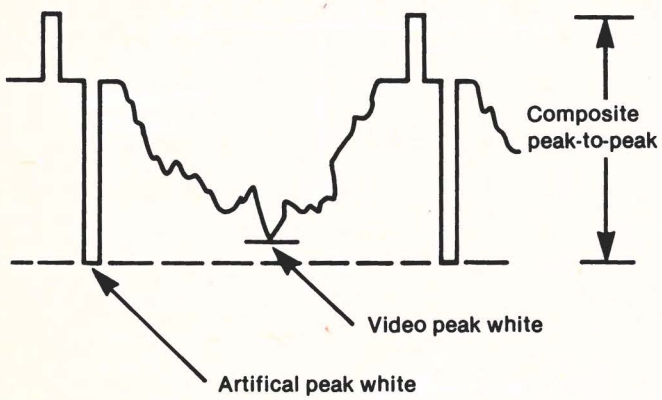
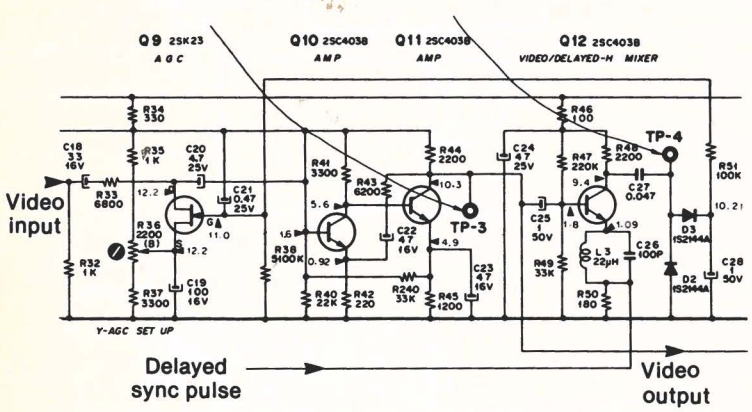
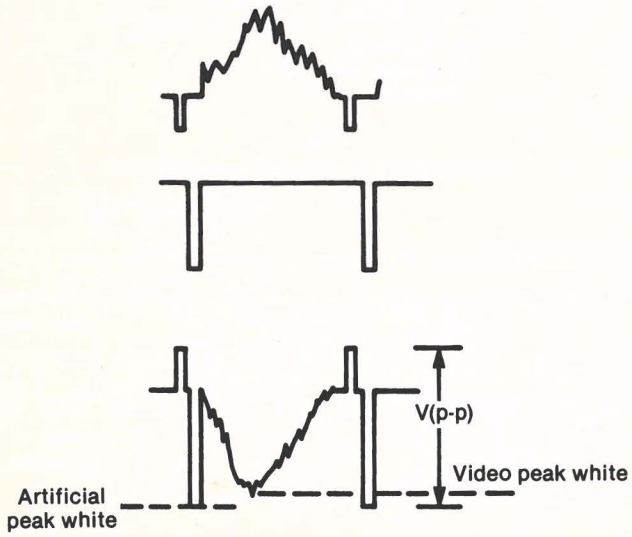


Fig. 12. Artificial peak white pulse makes AGC detector ignore actual video peak.



(a)



(b)

Fig. 13. Luminance AGC system injects artificial peak white signal to determine full peak-to-peak signal into AGC detector.

Luminance AGC. As mentioned earlier, the luminance AGC system must ignore changes in APL and respond to variations in sync amplitude to gauge the amplitude of the signal provided by the source. The system used on most Sony VTRs does the job by injecting an artificial peak white signal on the back porch of horizontal blanking. See Fig. 12. This spike is fixed in amplitude. The combined signal is applied to peak-to-peak detector, which produces a d-c control voltage proportional to the voltage span between sync tip and the peak of the artificial white spike. Since the white spike is fixed, only variations in sync amplitude will change the d-c output of the detector. Variations in APL that stay below the peak value of the artificial spike do not affect the peak-to-peak value.

Fig. 13(a) shows the circuit from an early U-matic. The artificial white spike is mixed with the video signal at Q12. Here video, with sync negative, is applied to the base and a negative-going delayed sync pulse is applied to the emitter. The signal at the collector is as shown in (b) of the figure. It is applied to a voltage-doubler rectifier that produces a d-c level across C28 that is proportional to the peak-to-peak voltage. This level is fed back to the gate of an FET control stage, Q9. This stage acts like a voltage divider formed by the series resistor R33 and the controlled source to drain resistance of the FET.

Low-Pass Filter. A low-pass filter precedes the active circuitry in the luminance channel to remove noise and signals above the NTSC video passband. This filter cuts off very steeply to ensure that high-frequency components do not produce beats and spurious response following pre-emphasis and frequency modulation. Fig. 14. shows the low-pass filter employed in a Betamax machine. Filter characteristics are usually considered proprietary and are seldom published.

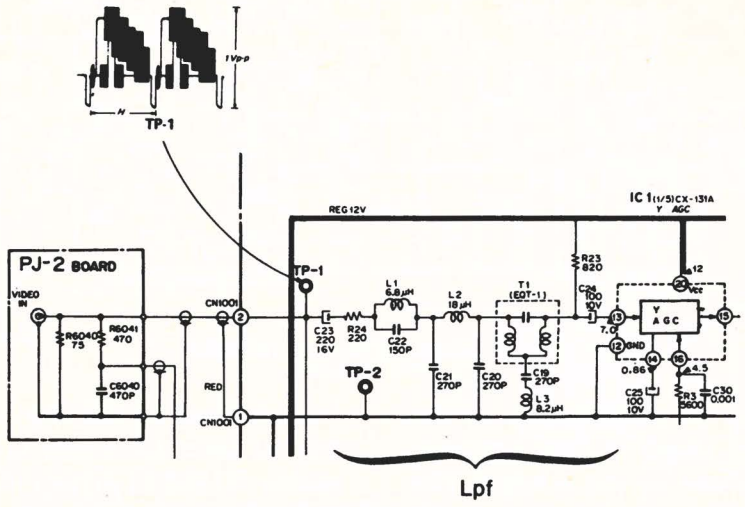


Fig. 14. Luminance-input low-pass filter.

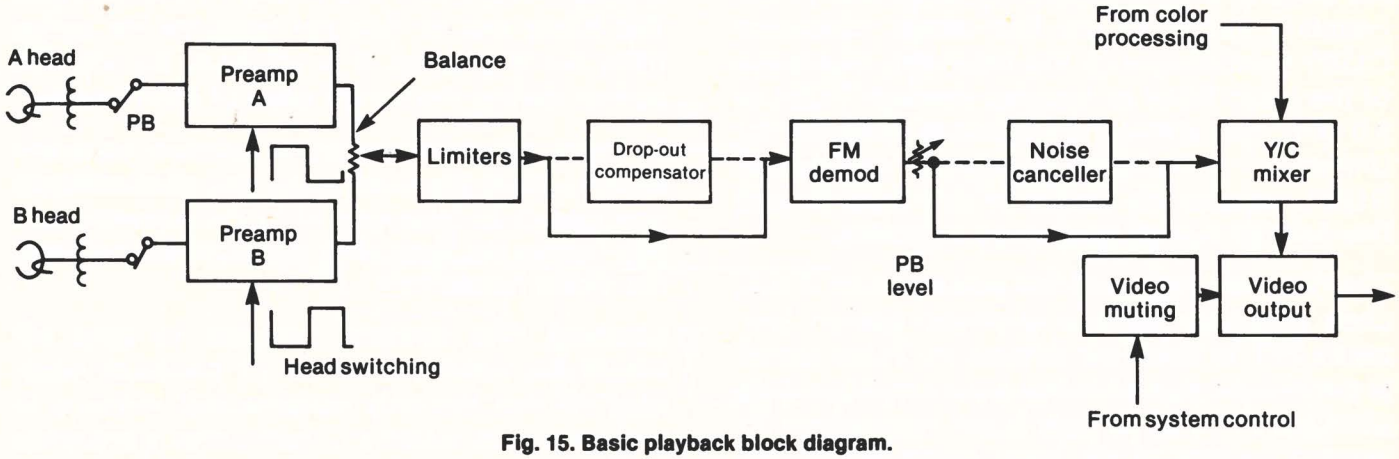


Fig. 15. Basic playback block diagram.

Playback Circuits. The basic job of the playback circuits is to raise the weak playback signal to the level needed to drive the limiters, demodulate the FM signal to restore luminance video, apply de-emphasis correction, reinstate the chroma signal at 3.58 MHz and supply standard output levels across 75 ohm loads. In addition video head switching is accomplished in the low level preamp stages. Fig. 15. shows the basic functional blocks. The blocks shown connected by dashed lines are ancillary functions that have become standard in Sony machines. They include a drop-out compensator that electronically fills in the holes in the r-f envelope, that result from dust and tape imperfections, with r-f information from the previous horizontal line that has been stored in a 1-H delay line. The noise canceller improves luminance signal-to-noise ratio by effectively separating noise, inverting it and then adding it back to the video signal. Muting is applied in videocassette machines to blank video during thread-unthread operations and at start up to give the servo time to lock before the picture is presented. Video muting in Sony machines is also applied when no control-track signals are detected. Thus a blank raster and not noise is produced when the end of a recording is reached on tape.

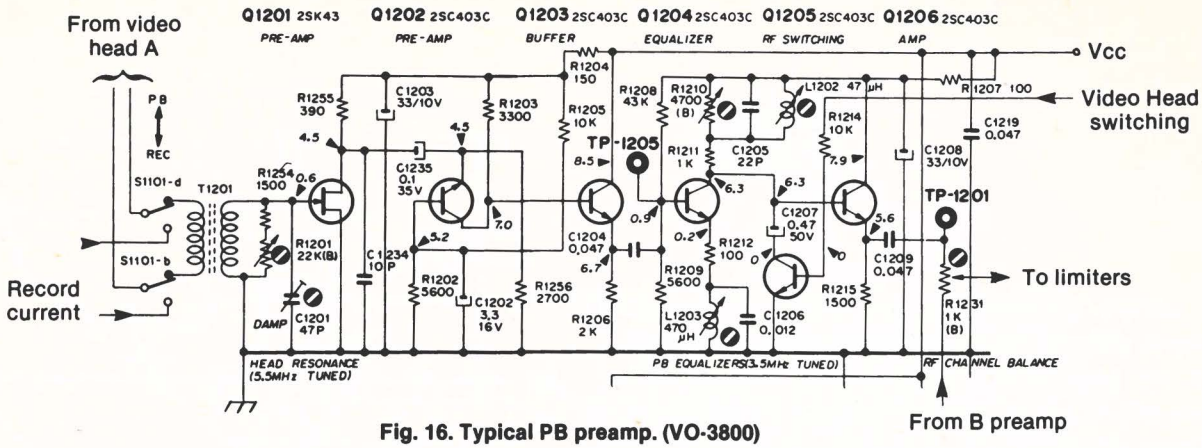


Fig. 16. Typical PB preamp. (VO-3800)

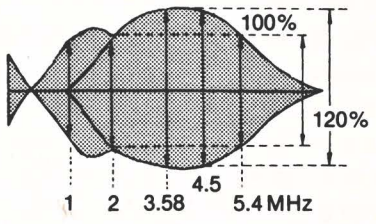
Playback Preamps. Fig. 16. shows one of the two playback preamps used in the portable VO-3800. This one is driven by the A head. The other preamp is identical and is driven by the B head. Both preamps are essentially low-noise wideband video amplifiers with response extending from a few kilohertz to just beyond maximum deviation. Various forms of peaking are used to extend frequency response. In the coupling circuit to the first stage, capacitor C1201 resonates with the inductive reactance of the video head as coupled through T1201 at 5.5 MHz, just above the maximum deviation for U-matics. A variable damping resistance, R1201, adjusts the height of this peak to give the desired overall frequency response.

The first two stages of the preamp form a cascode amplifier using a common source low-noise FET to drive the emitter of Q1202 which is connected as a common-base amplifier. This arrangement has a high input impedance to prevent loading of the input tuned circuit and yields the excellent noise characteristics of the common-base connection. An emitter follower, Q1203, provides buffering and impedance matching to video amplifier Q1204 which employs shunt peaking in its collector circuit in the form of L1202, C1205 and the variable-damping resistor R1210. This circuit is set to peak at 4 MHz with R1210 determining the overall effect on response. The resonant tank circuit L1203 and C1206 introduces local degeneration at 3.5 MHz to adjust the relative amplitude of 3.5 MHz and 4.5 MHz in the overall response curve. Fig. 17. shows what the overall response curve should look like using the video sweep signal recorded on the alignment tape as the signal source.

Video head switching is accomplished in the signal feed between Q1204 and Q1206. Transistor Q1205 is driven into saturation by the 30 Hz head-switching square wave developed in the servo system during the time that the B head is active. This effectively shorts the r-f signal path to ground through C1207. The switched signal is buffered by emitter follower Q1206 to drive one end of the r-f balance pot. The other end of this pot receives its signal from the B preamp. It is adjusted for uniform output during the active pass of both heads.

In many systems separate balance pots are used to drive the luminance and chrominance processors to take care of high-frequency and low-frequency (688 kHz) differences between the video heads.

Limiters. The limiters function to strip off amplitude variations in the r-f playback envelope so that the only variable that remains is frequency. In addition, harmonics generated by the severely non-linear stages help to partially restore upper sideband energy lost in the tape-playback process.



	Test point for Scope	5.4 MHz adj.	3.58 MHz adj.
CH-1	TP-1203/AV	R1216	R1224
CH-2		R1201	R1210

Fig. 17. PB preamp frequency response.

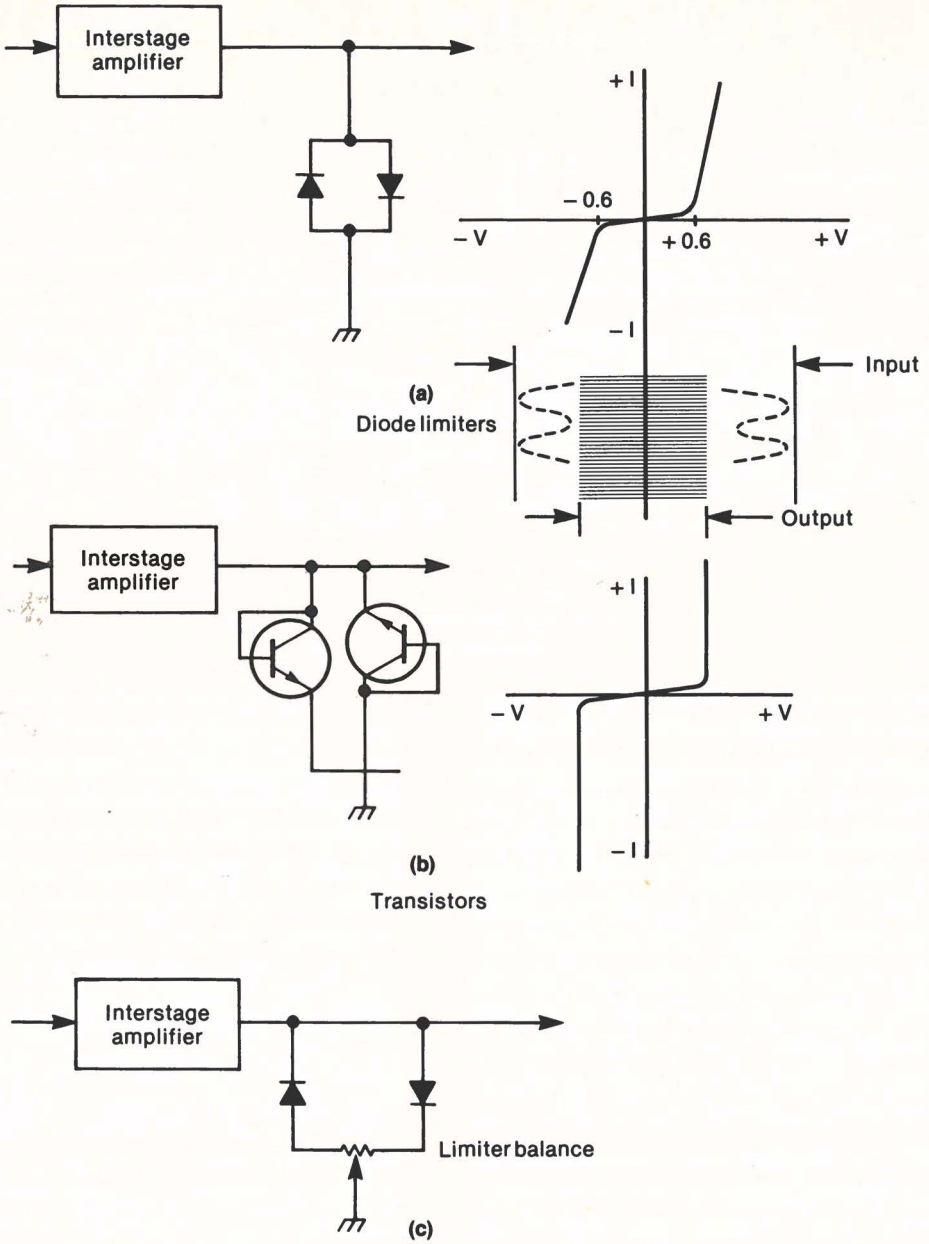


Fig. 18. Basic limiter circuits.

The limiter most commonly used in VRTs is a pair of diodes poled oppositely and connected in parallel. See Fig. 18(a). The diodes behave as open circuits below the barrier potential of 0.6 volts for silicon diodes. Voltage swings higher than 0.6 volts cause the forward biased diode of the pair to conduct, effectively shorting the signal to ground. The circuit shown in (b) of the figure is essentially the same except that the base-emitter junctions of transistors are used as the diodes. Heavily-doped emitter regions result in a much more abrupt "knee" in the forward characteristic. This results in better limiting action and greater restoration of upper sideband energy.

Several cascoded limiter stages are employed, with interstage amplifiers to drive each succeeding limiter stage. In some designs the final limiter has a balance potentiometer as shown in Fig. 18(c). This pot is adjusted to achieve symmetrical limiting action on both positive and negative signal swings. It is set tc equalize imbalance in the entire limiter chain and is one of the playback carrier-leak adjustments that maintain waverform symmetry into the FM demodulator.

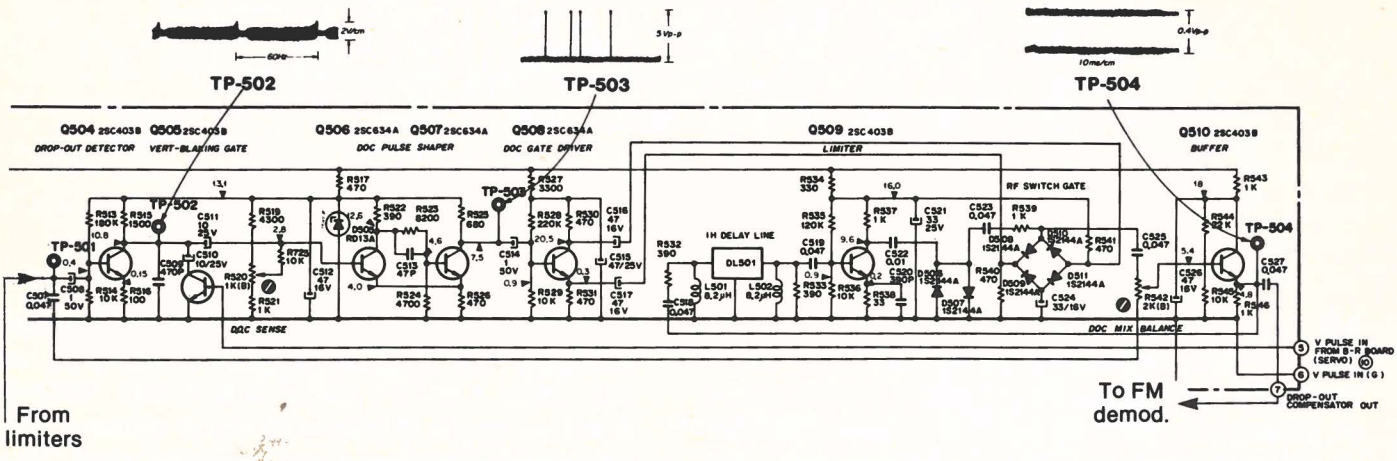


Fig. 19. Drop-out compensator. (Vo-1800)

Drop-Out Compensators. (DOC) Drop outs caused by dust particles, tiny areas of missing tape coating, and the like, cause sharp reduction in the playback output that appear as holes in the r-f playback envelope. They show up in the picture as random black dashes lasting but a tiny fraction of a line to several lines in duration. The most objectionable visual effect of these dropouts can be removed by filling in the holes from r-f information stored from a previous line. That's what the drop-out compensator does, and a circuit useful for instructional purposes is shown in Fig. 19.

The normal path for signal, in the absence of dropout, leaves the limiters at TP-501, goes through C507 to the bottom of the DOC mix/balance pot and through buffer Q510 to the FM demodulator. A sample of this signal, at TP-504, is fed back to the input of a 1 H delay line followed by another limiter (to offset the attenuation in the delay line). The signal from this limiter will be substituted for the normal signal route if a dropout occurs. The remainder of the circuitry detects the dropout and activates the switchover to the delay-line feed.

A sample of the r-f envelope at TP-501 is applied to the detector stage Q504. In the absence of signal this stage operates close to cutoff. Positive going r-f excursions bring the stage into conduction lowering collector voltage. Capacitor C509 filters the r-f output to maintain a low static collector voltage. Drop-outs are loss of drive to this stage, the d-c operating point returns to cut off and collector voltage rises. Hence, dropouts appear as positive pulses at the collector of Q504; the height of these pulses is determined by the depth of the dropout and pulse width is determined by dropout duration.

Detected dropout pulses are applied to a Schmitt trigger stage, Q506 and Q507. This a monostable multivibrator that switches to the unstable state and stays there as long as the input is above its trigger threshold level. R520 sets this threshold level. It is adjusted so that dropouts that exceed a particular depth (– 26 dB) will trigger that Schmitt MV.

At the output of the Schmitt are pulses of fixed amplitude but variable duration. The latter is equal to the duration of the dropout.

The gate driver develops negative pulses at its collector and positive pulses at its emitter. These are applied to the four-diode switch. These diodes are normally conducting and return the delayed output to ground through C524. The pulse output of Q509 back biases all diodes, lifting the route to ground and permitting the delayed signal to be routed to the top of the mix-balance control. The latter is set to maintain the same amplitude during normal operation.

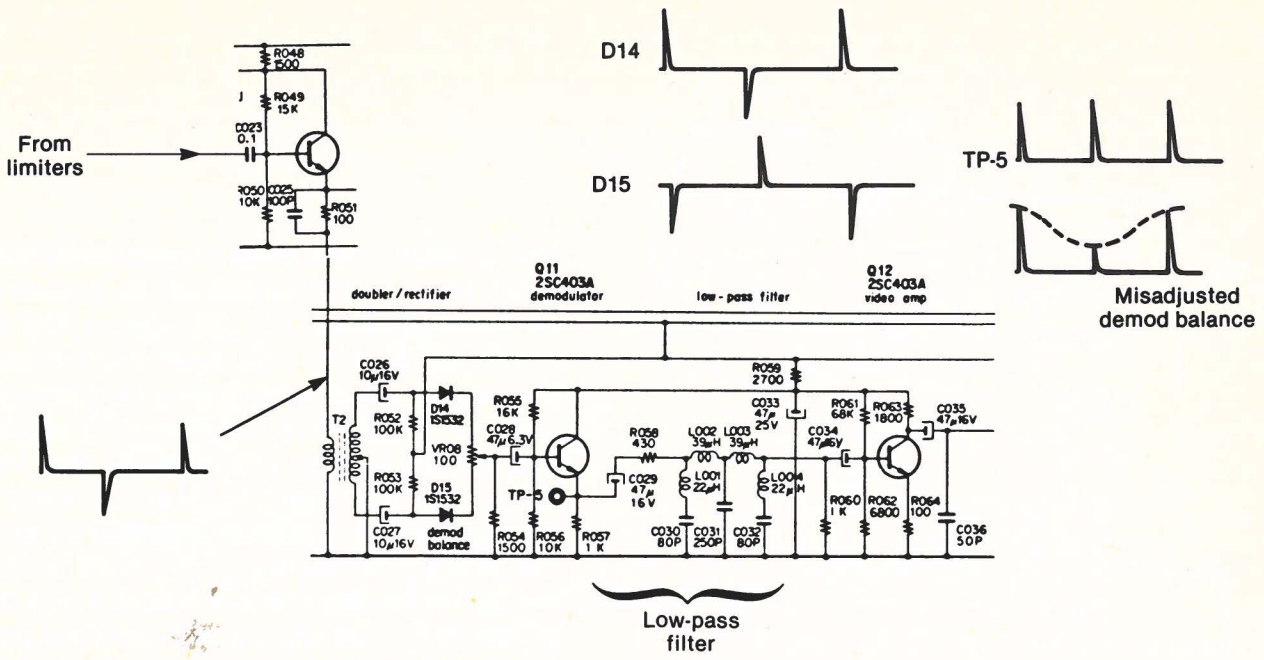


Fig. 20. FM demodulator.

In many systems the D.O.C. is disabled during the vertical blanking interval. Dropouts do not appear in the picture during this interval and the substitution of sync from a previous line can disrupt normal sync separation. In the circuit of Fig. 19, the D.O.C. is disabled during vertical blanking by Q505. This transistor is held in saturation, shorting the output of the dropout detector, by a vertical blanking pulse developed in the servo system. The start of this pulse coincides with video head switching to prevent the switching transient from triggering the D.O.C.

Note that the D.O.C. in Fig. 19. operates on the luminance signal only. This removes the most serious effects but does nothing to correct color during the dropout. In professional systems the D.O.C. operates in a time-base corrector, at the point where the total video signal is in digital form. An r-f envelope feed to the TBC is needed for dropout detection and the dropout is corrected in both luminance and chroma values.

FM Demodulators. The demodulators used in VTRs have two common characteristics. They are essentially pulse-count or pulse-density detectors in which the actual job of turning the variable density signal into video is done by a low-pass filter. Second, they operate to double the frequency of the carrier to place the carrier ripple well outside the video passband.

The easiest demodulator to understand is the circuit used in an early CV machine. See Fig. 20. Here the square wave delivered by the limiters is first differentiated by a short time-constant coupling network to form fixed-duration positive and negative spikes at the rising and falling transitions in the square wave. This produces one positive spike and one negative spike per cycle. The centertapped transformer provides feeds of opposite polarity to a pair of diodes that pass the positive spikes. But due to the opposite polarity drive, the diodes conduct alternately to produce two output pulses per input cycle. This is just like a full-wave rectifier which also doubles the ripple frequency. The output now contains constant-amplitude, fixed-duration pulses that vary in density only—closer together at high deviation, further apart at the low end of the deviation range. This signal, when integrated by the action of the low-pass filter, provides an output proportional to pulse density. The video signal appears at the output of the filter. The balance potentiometer equalizes pulse height from both diodes. It is easy to see, as shown in the detail, that an unbalanced setting produces a ripple component at the original carrier frequency. The balance pot is another playback carrier-leak adjustment.

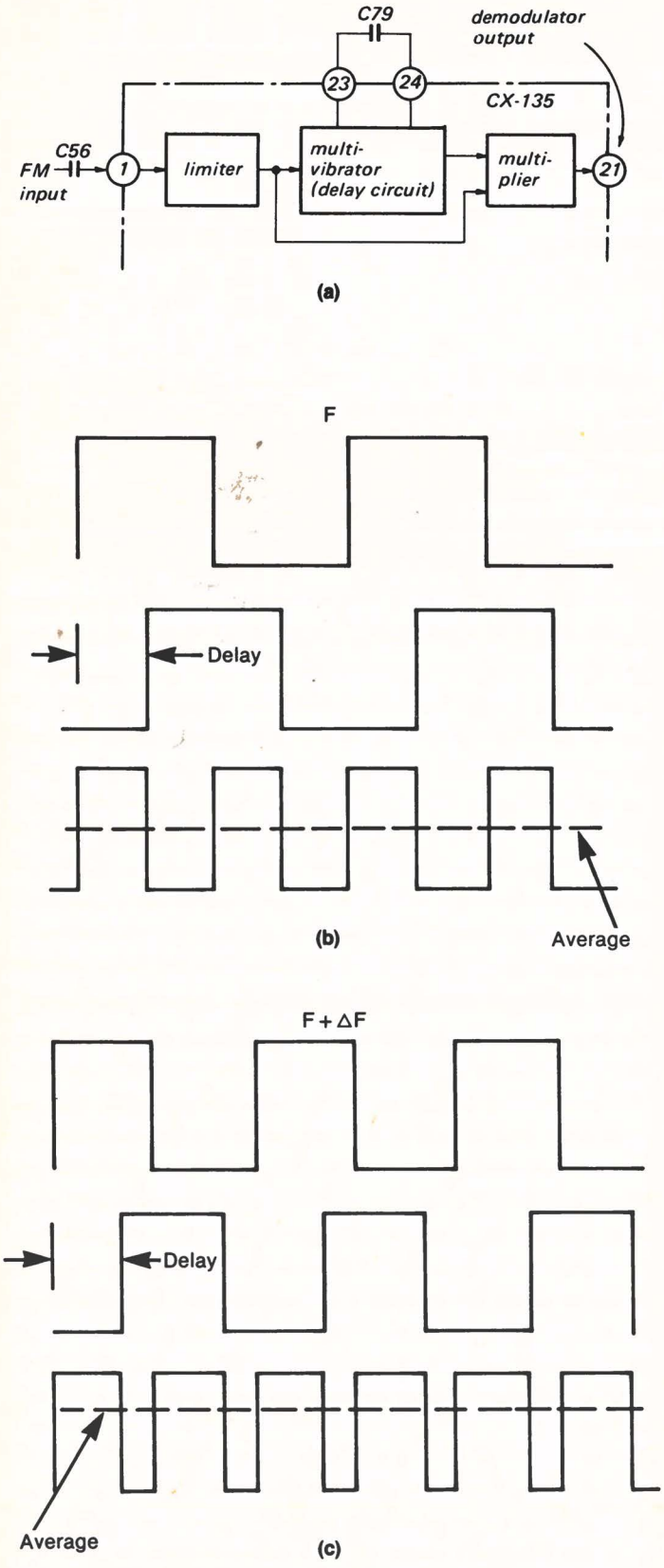


Fig. 21. Beta-type FM demodulator.

The demodulators used in later models employ delay lines or multivibrators to secure pulses of fixed duration. Fig. 21. shows the system employed in Beta and Type II U-matics. Here the square wave produced by the limiters is applied to a multiplier stage as well as an injection locked astable multivibrator that inserts a fixed time delay into the square wave that it produces. The multiplier acts like an exclusive OR gate producing an output when either input is high while the other is low. As can be seen by the multiplier output waveform in (b) of the figure carrier frequency is effectively doubled. At higher deviation values, as shown at (c), the effect is as shown and average output increases in a positive direction. This type of demodulator is far less sensitive to noise and does not require as much limiting as the earlier types.

De-emphasis and Playback Level. The playback level control follows FM demodulation. See Fig. 22. Video levels can be held to very tight tolerances in FM systems because variations in tracking, amplifier gain, head sensitivity, and so forth do not affect the frequency of the processed signal. Playback level is adjusted using the factory alignment tape as the playback source. Carrier frequency limits have been carefully controlled in making this tape. The level control is set for a standard output video level of 1 V(p-p) into a 75-ohm load.

De-emphasis is also applied following demodulation to restore flat video response. The de-emphasis network provides high frequency cut to offset the high-frequency boost prior to modulation. The RC network responsible for de-emphasis in Fig. 22. is R687, C610 and the output impedance of Q537.

Noise Cancellation. The basic action of a noise canceller is shown in Fig. 23(a). A sample of the video signal is applied to a high pass filter. This filter removes the low frequency components that form the steady-state values and passes both the high-frequency noise and the

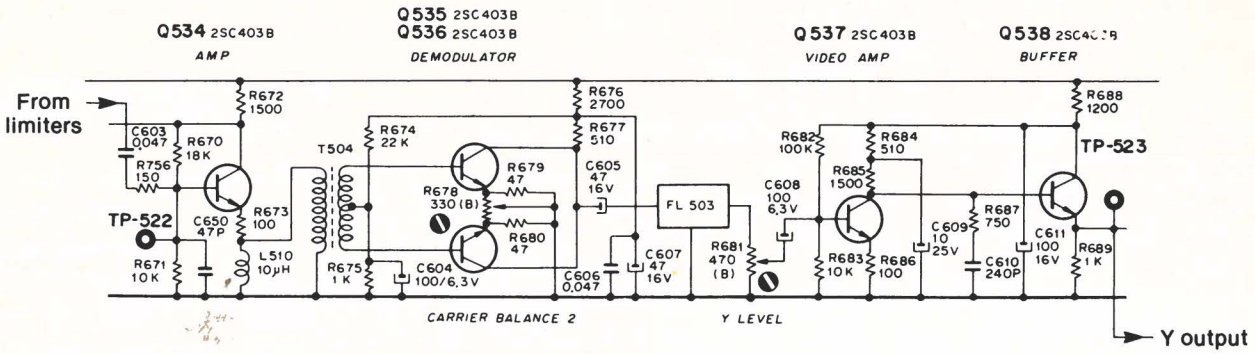


Fig. 22. Playback level and de-emphasis.

voltage spikes that represent the leading and trailing edges of vertical lines in the picture. Note that this results in a noise signal resolved around zero. A limiter stage shears off the spikes that represent video voltage transitions leaving primarily noise. This signal is then inverted and added back to the original video signal. Here the out-of-phase noise components subtract or cancel. The amplitude of the inverted noise must be set to equal noise in the main channel to effect cancellation. Too much inverted noise causes overall signal-to-noise ratio to deteriorate and the voltage spikes that have survived the limiter tend to degrade resolution.

Another approach to noise supression is shown in Fig. 23(b). Here the main route for video includes a low-pass filter that rounds off the transients at leading and trailing edges. A sample of the signal is also fed through a high-pass filter to separate noise and high-frequency transients. These are fed through a limiter that rejects the signals close to zero, passing only the high amplitude spikes that represent sharp video transitions. These are then added back to the video signal to restore video resolution. These systems are sometimes referred to as "coring circuits" because the noise is centered around a voltage "core" which is subsequently removed.

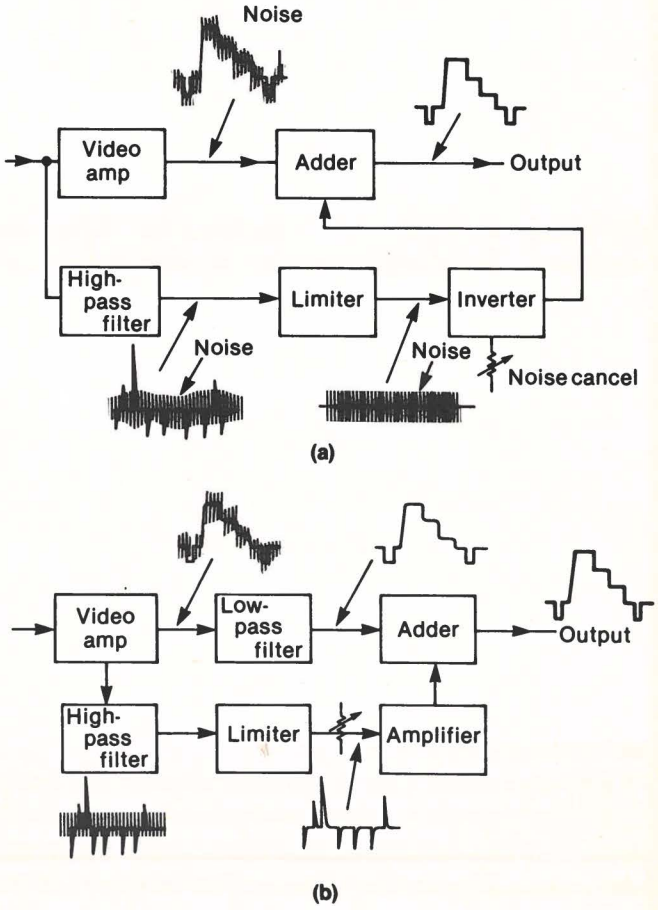


Fig. 23. Types of noise-reduction circuits.

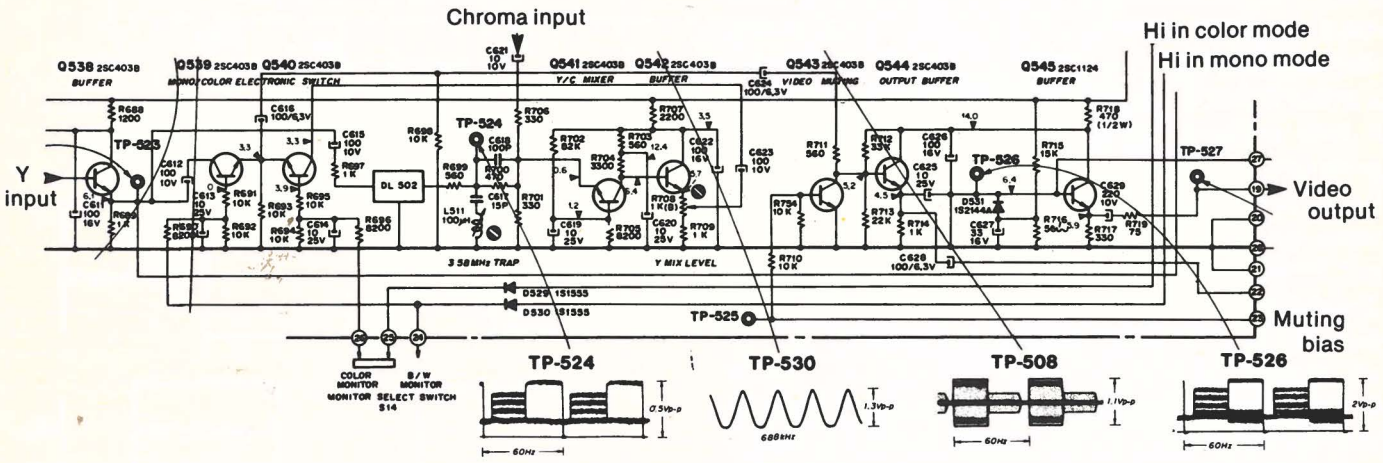


Fig. 24. Typical video output circuit.

Output Circuits. The remaining job is to rejoin the 3.58 MHz chroma signal with the Y signal and supply the composite signal to the output load. Fig. 24. shows a typical example. Video at TP-523 takes two routes; one directly to Q539 which is saturated in the monochrome mode. The second route is applied to a delay line which inserts a delay equal to the normal delay that the color signals experience in the narrow-band color circuits. A 3.58 MHz trap, C617/L511, follows to make sure that color signals that have survived in the luminance processor are not mixed with the color signals that have been properly handled in the color processing circuits. The addition of the Y and color signals takes place in the resistive matrix R700, R706 and R701. A control in the color processor (not shown) sets the correct Y/C ratio. The reconstructed signal is applied to a non-inverting common-base amplifier to compensate for signal attenuation in the delay line, and then an emitter follower buffer. Output of the buffer is routed back to the color section of the color-mono switch Q540. This transistor is saturated in the color mode. R708 is adjusted so that video level in the color mode is the same as video level in the monochrome mode.

Output from either Q539 or Q540 is routed to buffer Q544. Signal developed at the emitter is routed to the VHF modulator via C628 and to a second emitter follower Q545. The latter has an output impedance of 75 ohms and feeds the video output connector. When Q545 is terminated properly, output is 1 V(p-p). If the output is open circuited video at TP-527 will be twice this value.

A transistor switch, Q543, saturates to short out the drive to Q544 when muting bias is applied. Muting bias is developed in the system-control circuits to blank the picture during threading and unthreading operations, and when there is no recording on the tape being played. The latter is detected by the absence of CTL signals.

2. BASIC LUMINANCE ADJUSTMENTS

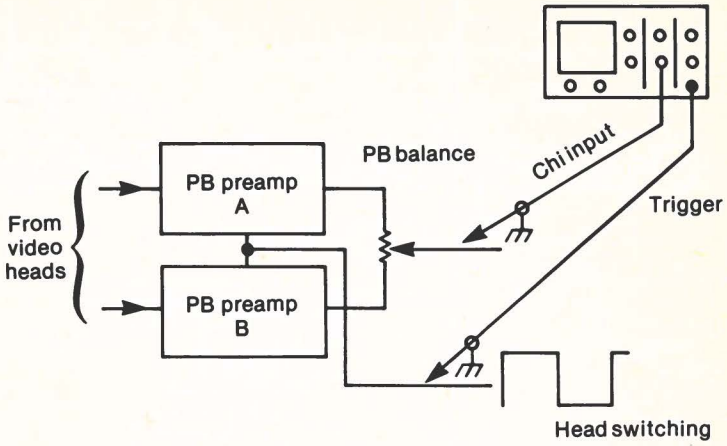
As in many other VTR adjustments, the basic philosophy is to use the factory-alignment tape to make the machine meet specifications in playback, then set record-circuit adjustments so that the machine duplicates these specs when playing its own tapes.

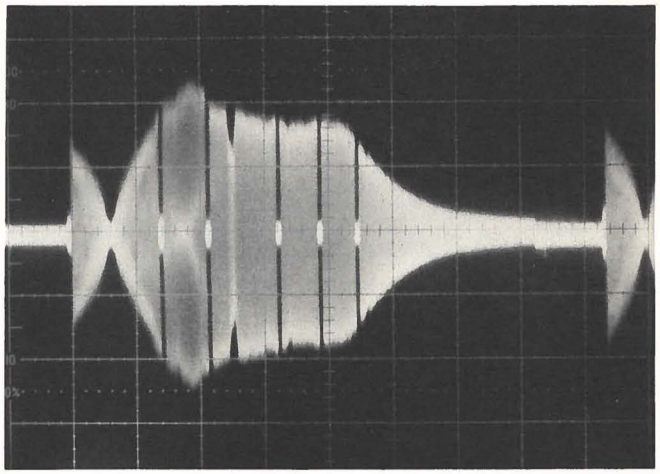
Playback Adjustments. Major adjustments in the sequence that is usually followed are:

- preamp frequency response
- preamp output balance
- playback level
- DOC sensitivity
- carrier leak.

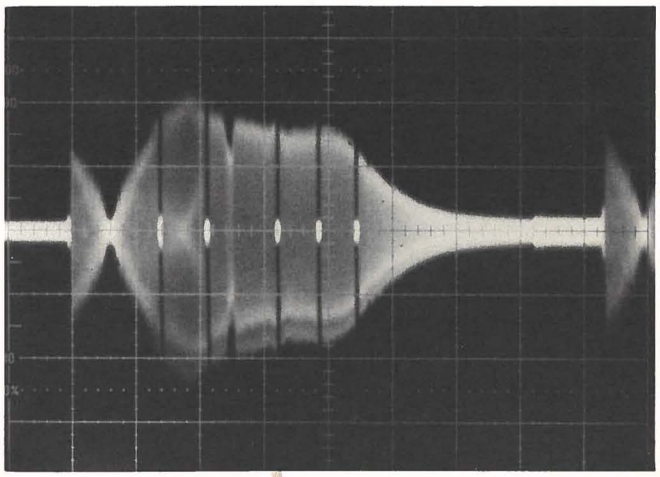
Frequency response is adjusted using the sweep signal recorded on the factory alignment tape. This recording uses dropouts in the sweep envelope as frequency markers. To view the sweep signal the scope is connected to the output of the preamps, at the arm of the balance pot, and the scope is triggered by the 30-Hz head switching signal from the servo system. See Fig. 25(a). Eigher A or B preamp signals can be viewed by selecting positive or negative slopes for triggering at the scope's sync controls. Adjustments should be made to secure the desired overall response, but preliminary adjustments minimize tuned-circuit damping so that the resonant frequencies of the head and peaking circuits can be more easily identified and located.

By triggering the scope from a 60 Hz source, such as the DOC blanking signal, it is possible to superimpose the response envelopes from both A and B channels and to make the response in both channels nearly identical. See (b) of the figure. This method can also be used to achieve proper setting of the balance control.





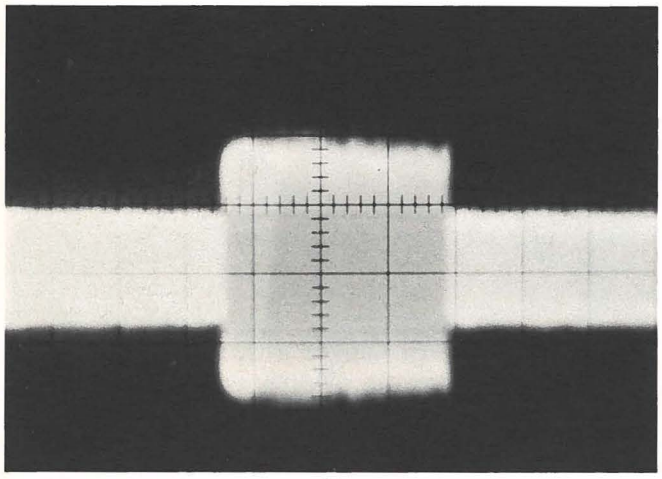
(a)



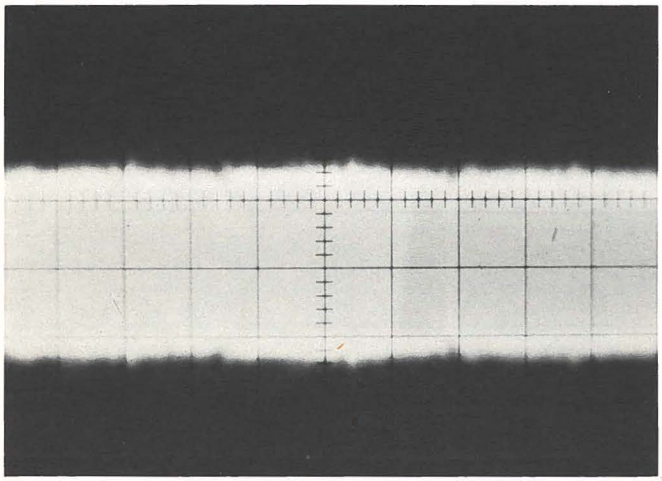
Trigger
60-Hz DOC
blanking

(b)

Fig. 25. Video sweep signals check PB preamps.



(a) incorrect



(b) correct

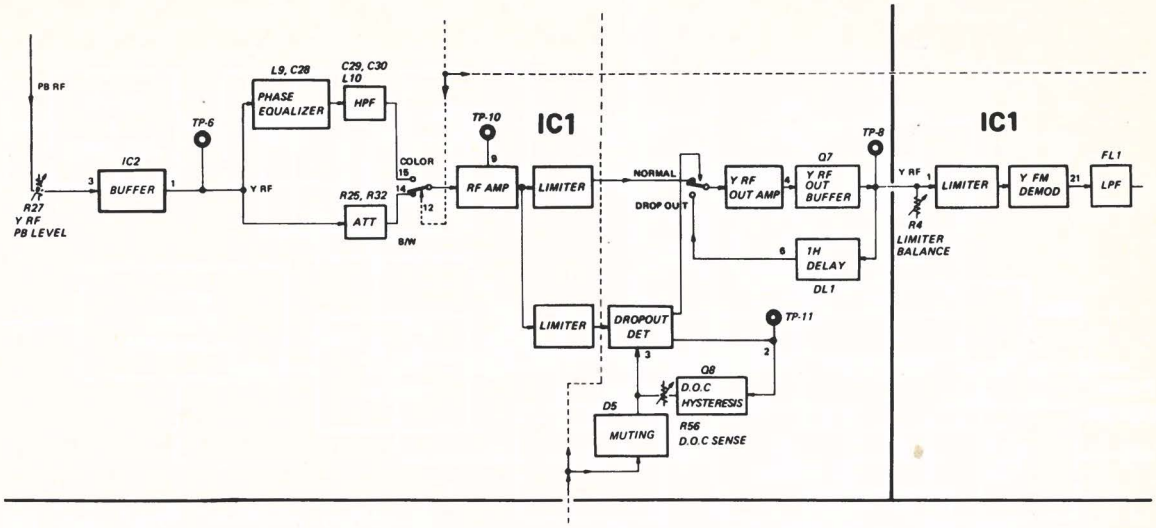
Fig. 26. PB balance adjustment.

Preamp balance can be set as outlined above, but the usual method is to view the output of the preamps at a point down stream from the balance pot, and using the monoscope part of the test signal, adjust for equal amplitude envelope through both A and B intervals. See Fig. 26.

Playback level is set by monitoring the video output when a 75 ohm termination has been connected to the output jack. The monoscope part of the signal is then played and output level set for 1 V(p-p).

D.O.C. Sensitivity adjustment sets the threshold of the Schmitt trigger for triggering at a particular signal level. This is done in the factory with a special signal generator that simulates dropouts of calibrated depth. Several methods have been devised for field adjustments that rely on the somewhat inexact use of "a tape with a lot of dropouts." The method that is now used makes use of the trail-off in frequency response when the sweep section of the alignment tape is played back. See Fig. 27. A dual-trace scope monitors the output of the preamps (top trace) and the output of the dropout detector (bottom trace) simultaneously. The bottom waveform shows positive-going excursions each time the envelope drops below the trigger level. This occurs at the zero point on the sweep, at each of the "dropout" markers, and finally at the point where the frequency response falls to the point where it triggers the Schmitt. The latter is used for calibration purposes. The scope is put into the add mode and expanded. Now the positive going transition shows the r-f level at which triggering occurs. Sensitivity is adjusted so that the step or transition occurs at a particular envelope level, 0.07 to 0.1 volts in the example shown.

Carrier-leak adjustments are limiter balance and demodulator balance pots. They are set by observing the playback stairstep signal and looking for high-frequency beat on the flat part of the steps. The controls are then adjusted to minimize this beat to form as thin a line as possible.



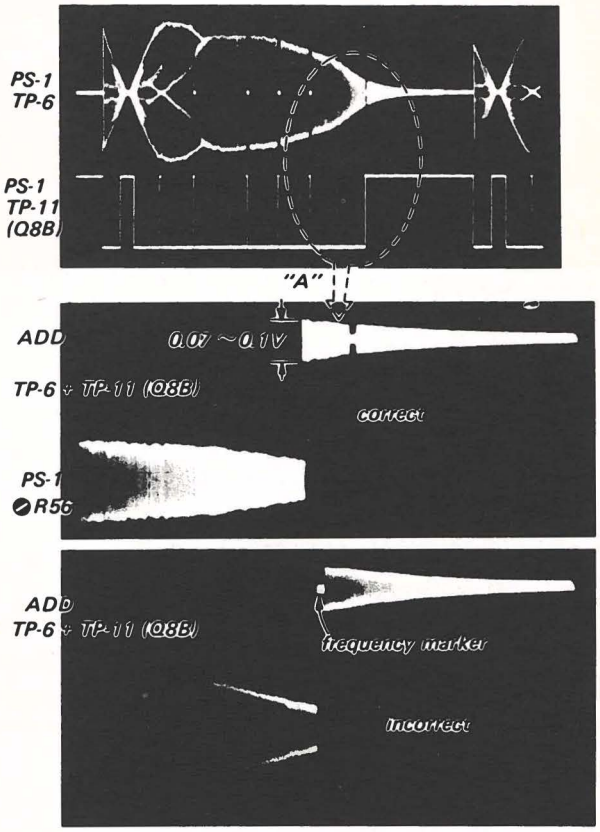


Fig. 27. D.O.C. aensitivity adjustment makes use of falling high-frequency sweep response.

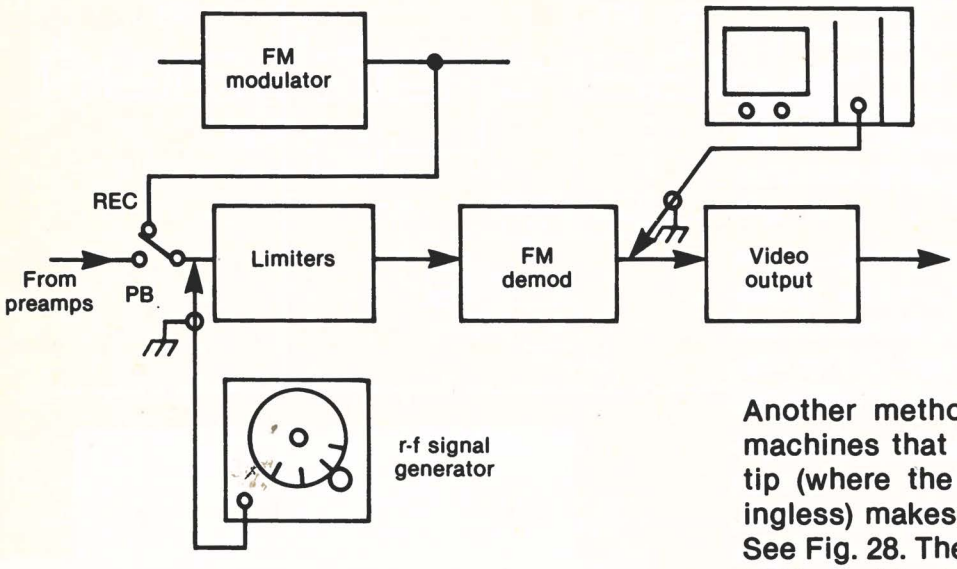
Record Adjustments. Major adjustments made while the machine is in the record mode include, in the order given:

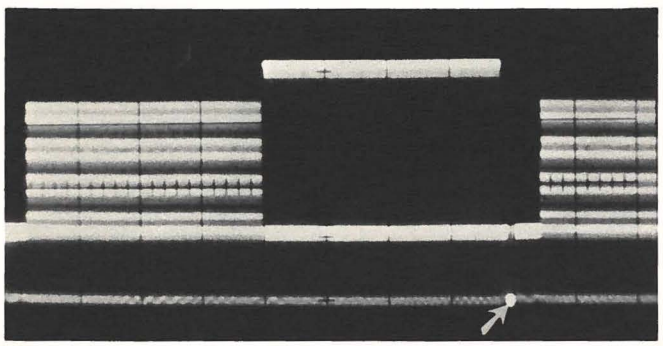
- sync tip carrier frequency
- maximum deviation
- carrier leak (waveform symmetry)
- white clip level
- record current

Sync tip frequency and deviation set the limits between which the FM modulator operates. In preparation for these adjustments the white and dark clip potentiometers are turned for minimum effect. This can be seen by monitoring the video input to the modulator in most cases.

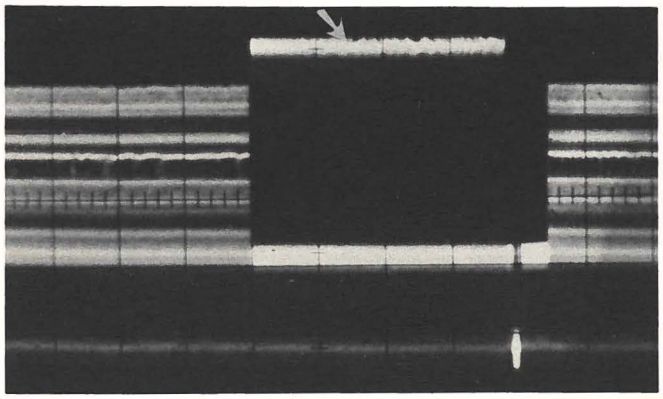
In those units that do not employ keyed clamps, the sync tip frequency can be set by simly removing the input video signal and checking the output of the FM modulator with a counter. The counter should be connected sufficiently down stream from the modulator to prevent loading and/or mistuning by the probe.

Following the sync-tip adjustment, deviation can be set by reapplying the video input signal and making several trial recordings with deviation set at small increments within the range of values observed at the input to the modulator. A record of each increment is recorded by voice on one of the audio channels. The tape is then played back and the setting that results in standard output, 1 V(p-p) is noted. The deviation control is then reset for the noted value.





Sync tip zero beat



Peak white zero beat

Fig. 28. Heteroyne method of setting deviation limits.

Another method that can be used in those machines that employ keyed clamps for sync tip (where the no-signal frequency is meaningless) makes use of a heterodyne principle. See Fig. 28. The method can only be applied in VTRs that feature full E-to-E operation, that is when the FM modulator signal is routed to the input of the limiters in the record mode. A CW signal from a test oscillator is fed into the limiters along with the modulator signal, and a video signal containing a 100% white bar is applied at the video input. A scope is used to monitor output of the FM demodulator, and time base controls are set to observe one or two fields of video. The test oscillator is then set to the sync tip frequency and oscillator output advanced to produce a band of beat signals at the sync tip part of the waveform. Carrier set adjustments are then made to produce a zero beat at the sync tip level, as shown in the waveform photo. The zero beat is quite easy to see because audio signals are easily displayed at this sweep speed. The test oscillator is then set to the peak-white frequency and deviation adjusted to produce a zero beat at the peak white level (top of the waveform in this case).

Waveform symmetry or carrier balance adjustments have been shown more effectively on the tape for this lesson. However, it should be remembered that if waveform symmetry had to be corrected, frequency will change. Thus the sync-tip and deviation adjustments would have to be rechecked. Record current and white clip settings have also been shown in Tapes 4 and 7 respectively and need not be repeated here.

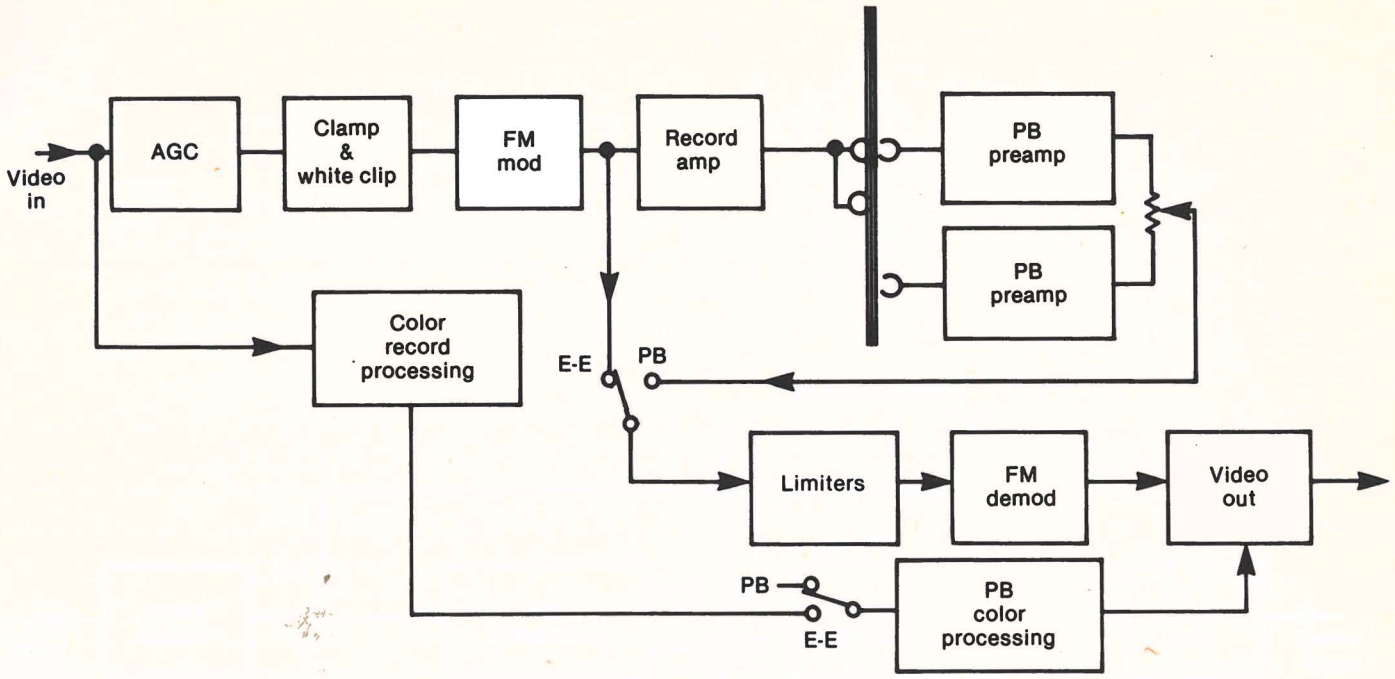


Fig. 29. Video E-to-E signal route.

3. E-to-E

The term *E-to-E* means electronics-to-electronics. Functionally, it provides a means of monitoring a recording in progress, in that samples of the input video and audio signals appear at the output jacks of the machine when the record button is depressed. This permits the operator to observe the program both before the recording has actually begun and while the recording is in progress. Recordings do not begin until tape is actually moving, after both RECORD and PLAY (or FORWARD) buttons have been depressed simultaneously.

The meaning behind the E-to-E term comes from the signal route. All record and playback circuits are active except the actual record amplifiers that drive the video heads. See Fig. 29. The signal path then includes FM modulation and demodulation, only the record amplifier and playback preamps are bypassed. This gives the operator instant confirmation that most of the circuits in the processing chain, including the color circuits, are functioning normally. It is also a great trouble-shooting aid. A machine that makes a normal E-to-E picture, but fails in actual record or playback has the problem localized to two circuits, the wire route to the video heads, and the video heads themselves.

E-to-E operation is also a great aid in making adjustments because many of the record-circuit adjustments, except for record current, can be made with the machine in the E-to-E mode. That is, with the RECORD button depressed, but the PLAY (or FORWARD) button not.

The transition from E-to-E to RECORD is accomplished by holding down the RECORD button and then depressing PLAY or FORWARD. This starts tape movement but also activates the video and audio record amplifiers and the bias-erase oscillator by controlling supply voltage to these circuits.

True E-to-E operation is employed in all industrial and professional VTRs such as the U-matics. It is not used in home video-cassette machines such as the Betamax, although the term E-to-E remains in use to describe the setup that routes input signals to the output jacks when the RECORD button is depressed. In this case however, the signal route bypasses much of the signal processing circuitry, as shown in Fig. 30.

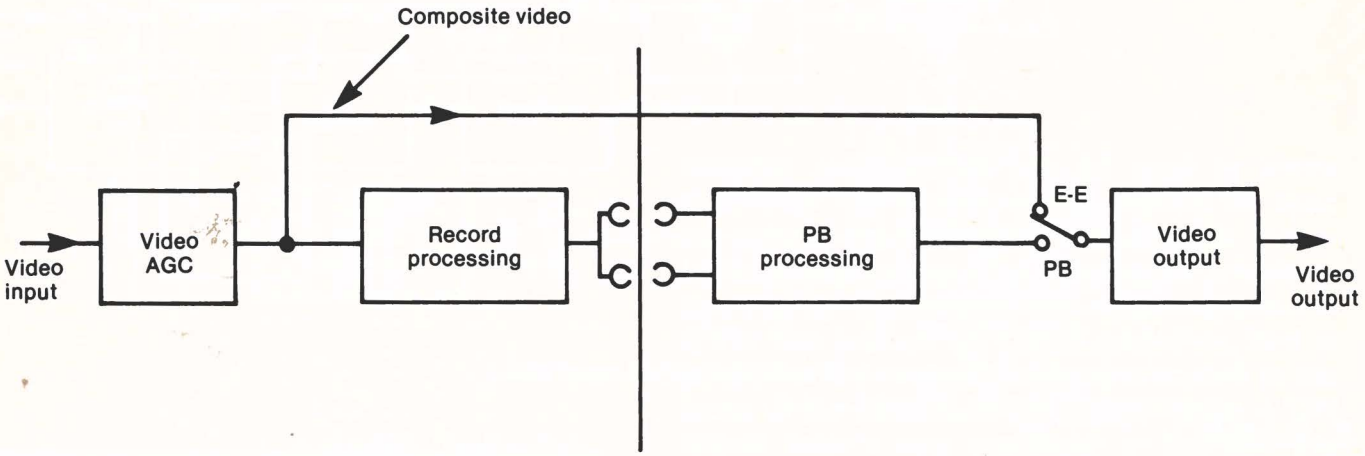


Fig. 30. E-to-E route in home videocassette machines.

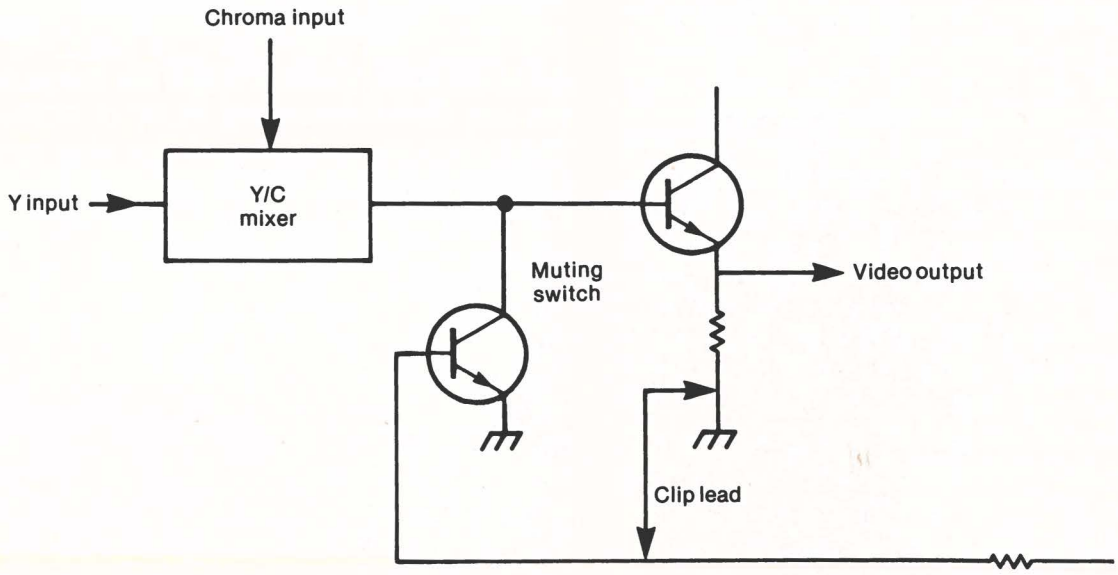


Fig. 31. Muting defeat.

4. MUTING

Video and audio muting are applied in videocassette machines to cut off picture and sound during threading and unthreading operations. In addition, muting is extended in time following tape threading or the start of PLAY to give the tape time to come up to speed, and the servo systems to lock, before the picture is presented for viewing.

In Sony machines video muting is also applied in the PLAY mode if control-track signals are not played back. This yields a blank raster if tape playback extends beyond the point where the tape has been recorded. In the absence of CTL muting, the monitor would display noise (snow) under these conditions. CTL muting is not applied in machines made by some other manufacturers. These display a snowy raster after the end of a recorded section of tape has been passed. Audio muting is not applied in Sony machines in the absence of CTL pulses. Thus the machines can be used as audio-only playback devices, if required.

Muting is applied by means of a d-c control voltage developed in the system control section. Here the switch closures that signal the end of tape threading, and the supply of control track pulses from the servo system are monitored. The necessary time delays are also developed in system control.

The control voltages are applied to transistor switches in the output circuits. One example was shown earlier, Q543 in Fig. 24. In many cases it is necessary to disable muting for troubleshooting purposes. For example, a blank raster in playback could be due to a defective CTL head and not a fault in the video playback circuits. Muting is disabled in most Sony VTRs by shorting the muting-control bus to ground on the video processing board. See Fig. 31. Resistors in series with the source of control voltage (in system control) preclude damage by shorting the bus at this point.

5. TROUBLESHOOTING CONCEPTS

Luminance processing introduces a new set of trouble symptoms because of the FM modulation process. But these can be quickly related to the problem area by translating what you have learned to the cause of visual effects.

Record/Playback. First of all, problem localization starts with comparisons of machine performance in the playback, record, and E-to-E modes. A machine that produces a normal picture when playing back an alignment tape, or any tape known to be good, but shows some picture fault when playing back its own recordings obviously has a fault in the record circuits. This is an important first step in localizing a problem.

Playback Troubles. We are confining ourselves to luminance problems in this booklet, problems that prevent a normal black and white picture on the monitor. Some common problems are complete loss of picture, noisy (snowy) pictures, flicker, loss of resolution and various forms of beat interference.

Complete loss of picture is a break in the signal path. If the E-to-E picture is normal the break must be before the point in the signal path where the E-to-E signal is fed into the playback circuitry (usually before the limiters). Remember to disable muting in playback to eliminate this source of trouble. The fault could be in system control.

Snowy pictures indicate loss of drive at the inputs to the video heads. The preamps have to be working to amplify the tiny electrical signal generated by thermal noise, so the trouble must be loss of drive to these high-gain stages. A very common cause is video heads clogged with oxide debris from the tape. Head cleaning will solve the problem in most cases; if not, the heads require replacement. Failure of one head results in a snowy picture with considerable 30-Hz flicker.

Thirty-Hz flicker that appears in peak-white parts of the picture suggests a loss of upper deviation FM in one of the playback preamps. A misadjusted or defective head-resonance capacitor can cause this problem by reducing the output of one preamp at the high end of the deviation range. The result is a loss of signal-to-noise ratio in one channel. Hence the flicker in the peak white parts of the picture at the 30 Hz rate. Flicker that is not confined to white areas suggests unbalanced output from the preamps.

Loss of resolution can be caused by bandwidth restriction both before and after the FM demodulator. Likely areas that can be checked easily are the playback preamps (using the sweep section of the alignment tape), and the noise canceller. If these prove to be o.k. the limiter, FM demod and video amplifiers should be checked with a wide band scope while looking for a rounding and loss of rise time at signal transitions.

Noise in particular parts of the picture as well as *herringbone* beats, or *beats* that are also confined to the leading and trailing edges of objects in the picture, indicate severely restricted bandwidth in stages preceding the demodulator or excessive carrier leak. A fault that severely cuts into the high-frequency response of the preamp, for example, produces a symptom that looks like overdeviation. Except that here deviation is normal but the playback circuits produce only noise in the maximum deviation range. Noise in highlights and on the edges of vertical lines in the picture when the alignment tape is played, point to this difficulty.

In modern VTRs misadjusted playback carrier-leak adjustments produce fine, high-frequency beat patterns that can be seen only on wide-band monochrome monitors. However, severe imbalance, such as failure of one of the diodes in a balanced FM demodulator, results in very strong carrier signals surviving the low-pass filter after the demodulator. In some cases this signal can be so strong as to drive a video amplifier into nonlinear operation. This results in a negative picture with a heavy herringbone pattern.

Another source of beat is outside interference from signal sources operating within the FM passband and picked up in the video-head wiring.

Record Troubles. A machine that displays faults in the black-and-white picture when playing back its own recordings, or when its recordings are played in a machine known to be in good shape, has a fault in its record circuits. Here again, a look at the E-to-E picture can help in localization. For example a normal E-to-E picture and snowy playback of actual recordings, points to failure of the record amplifier. Refer back to Fig. 29. Insufficient record current will result in noisy playback of recordings.

Other circuit faults peculiar to the record circuits are centered on the FM modulator and its input drive circuits. Consider the effects of incorrect deviation or mislocated deviation. Excessive deviation, or correct deviation from too high sync tip frequency drives the modulator higher in frequency than can be handled by the playback system. The results are small smudges of noise on white highlights and at the edges of abrupt transitions in the picture.

Insufficient deviation results in a smaller voltage swing between sync and white, a drop in picture contrast. A sync-tip frequency lower than it should be increases the visibility of carrier leak and can cause beat problems with the color signal. A routine check of sync tip frequency and maximum deviation picks out these faults easily. Insufficient deviation can be traced back to a fault in the AGC system.

Although white clip is designed to prevent overdeviation, a faulty or misadjusted circuit can result in excessive clipping where peak white parts of the picture are sheared off. The symptom is a low-contrast picture with highlights losing details. Faces, for example, look like blobs of featureless white.

As you can see, the interpretation of symptoms is fairly straightforward when you know the functional role of each block in the system.

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Booklet 7
Glossary of Luminance Processing

ACK, Automatic Color Killer—An electronic circuit used in video processing which detects the presence of color burst in the complex video and switches color circuits in, or out, accordingly.

AGC, Automatic Gain Control—An electronic circuit which uses feedback to control a variable gain amplifier. This circuit will provide a constant level output.

APL, Average Picture Level—A measure of the average brightness (luminance level) of a scene.

Carrier Balance Control—An adjustment to minimize carrier leak and increase waveform symmetry by balancing vital RC values in a modulator.

Carrier Leak—Residual carrier which appeares in the video signal. Loss of symmetry in the carrier results in incomplete cancellation of the carrier in demodulation, leaving residual energy at the carrier frequency.

Carrier Set—A variable resistance which is used to set kthe DC level of the sync tip clamp circuit.

Cascode Amplifier—An amplifier using a neutralized grounded-emitter input stage followed by a grounded-base output stage.

Clamp Circuit—An electronic circuit which references the lowest level of a signal (in video, the sync tip), to a specified DC level.

Class A Amplifier—A class of transistor amplifier in which the transistors are always biased into conduction, in the middle of their linear operating characteristics.

Clip circuit—An electronic circuit which limits (clips) all signals above a specified level. This circuit will "square off" sinusoidal waveforms and transient pulses and establish a maximum output level.

Drop-Out Compensator—An electronic device which fills in the holes in the RF envelope. These holes resulting from dust and tape imperfections are placed with RF information from the previous line which has been stored in a 1-H delay line.

E-to-E—Electronics-to-Electronics, which describes monitoring a recording in progress with output samples of modulate/demodulated video, and audio, appearing at the output jacks.

FM Demodulator—A circuit which retrieves the modulating signal from a modualted carrier. In VTRs these circuits act as pulse density detectors and carrier frequency doublers which recreate the original video signal by passing them through a low-pass filter.

Knee—An up or down bending between two relatively straight curves, for example, the voltage level at which the conduction of a P-N junction shows a marked change.

Limiter—A clipping circuit which strips off amplitude variations in an R-F envelope, leaving only a frequency modulated waveform.

Luminance—Photometric brightness of any surface as measured or viewed from a particular direction; all the values between black and white encoded in the video signal.

Luminance Processing—The electronic circuits in a video system which separate, prepare, modulate, record, retrieve and recombine the brightness information in a video signal.

Pre-equalization—In video, boosting the low end of the frequency spectrum of a video signal before processing to compensate for low frequency roll-off in playback.

Pre-emphasis—An RC network which boosts high frequency before or after the carrier set clamp which serves to increase the signal-to-noise ratio.

Video Muting—A VTR feature which electronically blanks video (produces a black raster), during thread-unthread operations, machine start up time and whenever playback of a recorded program ends.

VCO, Voltage Controlled Oscillator—A circuit which produces an output frequency which is a function of a control voltage. In a VTR, the FM modulator is a VCO.

SONY
BASIC VIDEO RECORDING COURSE
SELF-TEST NO. 7
LUMINANCE PROCESSING

(Circle your answer.)

1. The most common type of VCO used as the frequency modulator in helical-scan VTRs is the: (a) monostable multivibrator; (b) bistable multivibrator; (c) astable multivibrator; (d) varactor-diode tuned oscillator.
2. Voltage spikes at the transitions of a stair step signal observed at the input to the FM modulator are the result of: (a) pre-emphasis; (b) white clipping; (c) the luminance delay; (d) incorrect sync-tip clamp setting.
3. In Sony helical-scan machines, luminance resolution is best: (a) when new video heads are installed; (b) in the monochrome record/playback mode; (c) deviation is set below the specified value; (d) record current is set too high.
4. An increase in the overall amplitude of the input video signal: (a) increases deviation in both directions; (b) increases deviation in the downward direction only; (c) increases deviation in the upward direction only; (d) stretches sync only.
5. If the VTR is adjusted normally except for excessive deviation the symptom in E-to-E and playback of the machine's own recording will show: (a) low contrast; (b) high contrast; (c) poor resolution; (d) white clipping.
6. An error in the duty cycle of the FM modulator results in: (a) low contrast; (b) overmodulation noise; (c) white clipping; (d) carrier leak.
7. The output voltage of a double-diode limiter is: (a) dependent on signal amplitude; (b) 0.12 volts (p-p); (c) 1.2 volts (p-p); (d) half the input voltage.
8. The luminance-record AGC system responds to changes in: (a) overal composite amplitude; (b) APL; (c) average white level; (d) peak white level.
9. A high-pass filter switched into the signal feed between the FM modulator and the record amplifier: (a) prevents overdeviation; (b) boosts the FM upper sideband; (c) makes spectrum space for the color signal; (d) prevents interference with the audio signal.
10. The drop out compensator: (a) automatically boosts gain during the dropout; (b) subsitutes r-f from an earlier part of the recording during the dropout; (c) switches in a 50% APL signal during the dropout; (d) mutes video during the dropout.

11. The carrier ripple frequency at the output of the FM modulator in a U-matic is: (a) 3.8-5.4 MHz; (b) 688 kHz; (c) 7.6-10.8 MHz; (d) above 15 MHz.
12. If the amount of inverted noise added back to the video signal in the noise canceller is set too high: (a) S/N improves; (b) contrast drops; (c) resolution suffers; (d) the picture becomes negative.
13. FM modulator sync-tip frequency is set in machines that use diode clamps: (a) with no video input signal; (b) using the factory alignment tape; (c) to twice the low-frequency limit; (d) by monitoring the d-c output of the demodulator in the E-to-E mode.
14. The first visible playback symptom of a U-matic with a faulty CTL head is: (a) blank picture; (b) mistracking; (c) no sound; (d) loss of servo.
15. A U-matic that produces a normal picture when playing the alignment tape and in the E-to-E mode but produces a very snowy picture when playing back its own recordings, probably has a fault in the: (a) luminance AGC system; (b) record amplifier; (c) FM modulator; (d) FM demodulator.
16. Playback video level is set using: (a) feed from an NTSC color-bar generator; (b) playback from the machine's own recording; (c) the factory alignment tape; (d) E-to-E feed.
17. A Betamax with a no luminance output in the E-to-E mode can have a fault in the: (a) FM modulator; (b) limiters; (c) FM demodulator; (d) video output stage.
18. Playback faults in the black and white picture that appear at a 30-Hz rate indicate trouble: (a) before the limiters; (b) in the FM demodulator; (c) in the noise canceller; (d) in the balance pot only.
19. A vertical blanking signal that starts at the head switching point is sometimes applied to the: (a) record amplifier; (b) playback preamps; (c) D.O.C.; (d) video AGC detector.
20. A symptom similar to that of overdeviation noise can result from: (a) excessive white clip; (b) low deviation; (c) restricted playback r-f bandwidth; (d) misadjusted noise canceller.

Answers:

1. (c)	6. (d)	11. (c)	16. (c)
2. (a)	7. (c)	12. (c)	17. (d)
3. (b)	8. (a)	13. (a)	18. (a)
4. (c)	9. (c)	14. (a)	19. (c)
5. (d)	10. (b)	15. (b)	20. (c)

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